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U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF ENTOMOLOGY—BULLETIN No. 104.
L. O. HOWARD, Entomologist and Chief of Bureau.

THE FIG MOTH.

BY

F. H. CHITTENDEN, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

REPORT ON THE FIG MOTH IN SMYRNA.

BY

E. G. SMYTH,
Entomological Assistant.

ISSUED NOVEMBER 4, 1911.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

FIG. 1.—SMYRNA FIG FROM NEW YORK CITY, SHOWING INJURY BY FIG MOTH (EPHESTIA CAUTELLA). (ORIGINAL.)

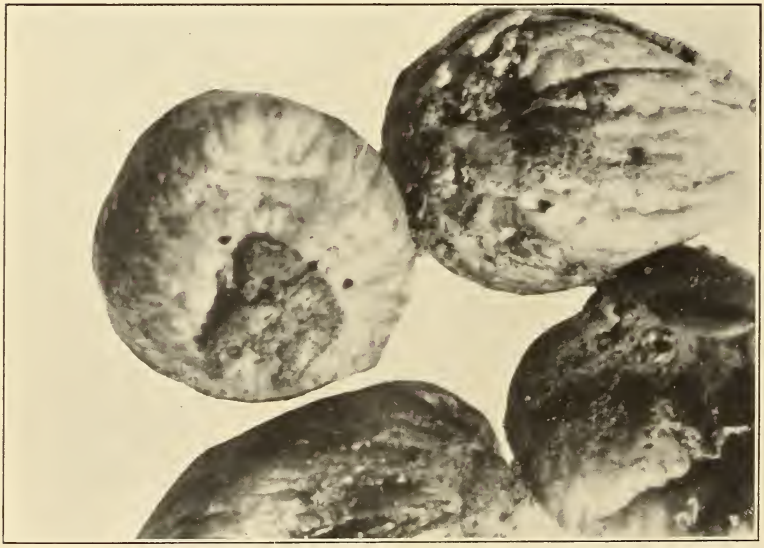

FIG. 2.—DRIED FIGS INFESTED WITH FIG-MOTH LARVÆ, SHOWING HOLES BORED THROUGH SKINS, ABUNDANT EXCRETA ADHERING TO FIGS, AND SINGLE LARVA AT RIGHT. (ORIGINAL.)

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---

[a] Transferred to cereal and forage insect investigations, Mar. 15, 1911.

LETTER OF TRANSMITTAL.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 2, 1911.

SIR: I have the honor to transmit herewith the manuscript of a bulletin dealing with the fig moth. It consists of two papers, the first, entitled "The Fig Moth," by Dr. F. H. Chittenden, in charge of truck-crop and stored-product insect investigations, and the second, entitled "Report on the Fig Moth in Smyrna," by Mr. E. G. Smyth, entomological assistant.

While the fig moth has been known in this country as a pest since 1897, at which time a short preliminary paper was published in regard to it in Bulletin No. 8, new series, of this bureau, it was not until 1908 that the insect attracted any great attention. It had by that time invaded mills of various kinds, including rice mills in the Southern States, and in these situations it is now quite a serious pest. In 1909 and 1910 thousands of dollars worth of figs were condemned by the Bureau of Chemistry under the law regulating the sale of adulterated or deleterious foods and drugs. This led the importers and dealers in Smyrna figs to request an investigation of the matter by the United States Department of Agriculture.

In pursuance of your directions Mr. E. G. Smyth visited Smyrna in Asia Minor to investigate the local conditions under which this important industry is carried on, and his report is embodied in the second paper of this bulletin. The work upon which the first paper is based was conducted by Dr. Chittenden in person, and this portion of the bulletin gives a very full general account of the insect.

The life history and food habits of the fig moth, as it occurs in the District of Columbia, where the weather in midsummer is not materially cooler than in Smyrna, have been thoroughly worked out, while the recommendations as to remedies are based upon actual experiments.

Particularly valuable among the remedies suggested would be the treatment of figs in specially prepared fumigatories located a short distance from the "khans" or buildings in which the figs are stored.

It has been found that bisulphid of carbon in a high temperature, ranging between 90° F. and 100° F., will kill practically all fig moths with an exposure of 24 hours, even with less of the fumigant than is usually advised.

I recommend the publication of these papers as Bulletin No. 104 of the Bureau of Entomology at the earliest possible moment, since there is urgent demand for this information on the part of merchants and growers interested in the culture, shipment, and sale of Smyrna figs.

Respectfully,

L. O. Howard,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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THE FIG MOTH.

By F. H. Chittenden, Sc. D.,
In Charge of Truck Crop and Stored Product Insect Investigations.

INTRODUCTION.

Prominent among the many species of insects which are being constantly shipped to this country from abroad is the fig moth (*Ephestia cautella* Walk.). Since 1908 this species has attracted much attention by its occurrence in various edibles in different portions of the United States, as well as in the mills of Texas and Louisiana. It has been concerned, with other insects, in considerable damage to rice, and reports are available of similar injury to flour and corn meal and other mill products, cotton seed, various other dried seeds and fruits, and other stored foods.

In the late fall of the year 1909, however, the species attained unusual prominence from the fact that the Bureau of Chemistry, working in pursuance of legislation on the pure food and drug law, seized numerous consignments and cargoes of figs in New York, Philadelphia, Boston, and some other large cities. This brought to light the fact that a very large portion of imported figs, especially such as are shipped from Smyrna, which port ships about 90 per cent of its total output to the United States, is found to be badly infested when reaching America. The dried figs in the market are frequently found to contain from 15 to 50 per cent and even higher percentages of infested fruit. These estimates, chiefly by the Bureau of Chemistry, are based partly on the presence of the insect, but largely on that of its excreta. The gravity of the situation became such in 1909 and 1910 that thousands of dollars' worth of figs were condemned, leading the dealers in Smyrna figs to request an investigation of the matter by the United States Department of Agriculture.

In accordance with the Secretary's direction, the following account of the fig moth has been drawn up, including a report, by Mr. E. G. Smyth, on the occurrence of the insect in what is perhaps its native home—Smyrna, Turkey in Asia. The writer's article deals primarily with the insect as a pest in stored products in America.

DESCRIPTION OF THE SPECIES.

Before proceeding to the description of the fig moth it should be stated that according to recent classification it belongs to the lepidopterous family Pyralidæ and subfamily Phycitinæ. Some writers give this subfamily full family rank and therefore call it Phycitidæ.

As to nomenclature, the species is now recognized as *Ephestia cautella* Walk., with the following synonyms: *cahiritella* Zell., *passulella* Barr., and *desuetella* Walk.

CHARACTERS OF THE MOTH.

This moth looks suspiciously like the congeneric *Ephestia kuehniella* Zell., the Mediterranean flour moth, and like *E. elutella* Hübn., as will be noticed by reference to the illustration (fig. 1), being of

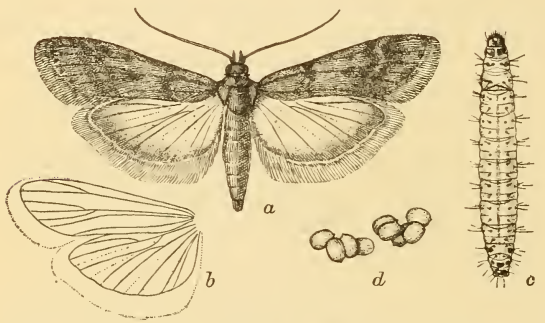

FIG. 1.—The fig moth (*Ephestia cautella*): *a*, Moth with expanded wings; *b*, denuded wings, showing venation; *c*, larva, full grown, dorsal view; *d*, two egg masses. *a*, *b*, *c*, About 4 times natural size; *d*, more enlarged. (Original.)

FIG. 2.—The Mediterranean flour moth (*Ephestia kuehniella*): Larva, dorsal view. (Author's illustration.)

a similar gray color, but it may be readily known from the former by the strong subdorsal line of the cilia of the hind-wings. The markings of the fore-wings are much more suffused than in the other two species, and the line across the basal third is whitish, more nearly straight, and bordered by a prominent, dark, suffused band. In the others this line is irregularly dentate or zigzag. The color of the fore-wings varies, some individuals being fawn color with scarcely any dark markings, while Ohio and District of Columbia series are considerably darker than either *kuehniella* or *elutella* and in some cases are very strongly suffused with reddish scales.

The following technical description of the moth is copied from Barrett:[3a]

[a] Numerals in superior type refer to corresponding numbers in the bibliographical list, p. 39.

TECHNICAL DESCRIPTION OF THE SPECIES.

Fore-wings narrow, especially at the base, costa less arched than in the preceding species [*ficulella* Barr.]. Costal lappet with a broad tuft of scales. Fore-wings pale fuscous with a yellowish tinge, scales large and coarse, and easily rubbed off. First transverse line at one-third the length of the wing, fuscous, ill-defined, straight, and very slightly oblique. Second line parallel with the hind margin, pale, faintly edged with fuscous, often nearly obsolete. Usual two dots on the disc oblique, fuscous, hardly discernible, cilia yellowish-fuscous. Hind-wings white, with scattered fuscous scales, and a faint brown margin, cilia white. Male with one ochreous tuft at the base. Head, antennæ, palpi, thorax and abdomen yellowish fuscous. Antennæ simple beyond the thick basal joint.

The wing expanse is from 14 to 20 millimeters.

DISTRIBUTION.

Like other species of the genus, the fig moth is supposedly of Asiatic origin. Judging from its abundance in Turkey in Asia that country would seem to be what Packard terms the insect's "metropolis;" in other words, its original or acquired locality of greatest abundance. However that may be, it is now, judging by published and office records, as well distributed as perhaps any of the Phycitidæ with the exception of the Indian-meal moth (*Plodia interpunctella* Hübn.), which is more nearly omnivorous in habit, and, therefore, more nearly universal in occurrence.

The known distribution includes Ceylon; Egypt; Smyrna, Turkey in Asia; China; Cochin China; Japan; Siberia; England; south-central and southern Europe; Venezuela; Guayaquil, Ecuador; Jamaica and Trinidad, British West Indies. In North America it is known in the following localities: Montreal, Canada; Milton, Mass.; New York, N. Y.; Washington, D. C.; Milwaukee, Wis.; Calla, Ohio; Hershey, Pa.; Guthrie, Okla.; Wichita, Kans.; Miami, Fla.; New Orleans, Morse, and Lake Arthur, La.; Galveston, Dallas, Sherman, San Antonio, New Braunfels, Fort Worth, Wichita Falls, Beaumont, Houston, McKinney, and El Campo, Tex.

DESCRIPTION OF THE EARLIER STAGES.

The egg.—The egg is whitish when first laid but turns after a few days to ochreous and, just before hatching, often, in parts, to orange. In form it is oval, sometimes approaching oblong-oval, often with a distinct nipple at one extremity. Its surface is subopaque, strongly rugose; the longitudinal rugæ are coarse, short, arranged in rather irregular alternating rows of about 24 and, with the transverse smaller rugæ, give a somewhat reticulated appearance. The smaller rugæ are fine and cilia-like, radiating from the longitudinal ones.

The egg is subject to considerable variation in form. Measurements of five eggs showed the following average:

Length, 0.33–0.38mm.; width, 0.22–0.32mm.

Two groups of eggs are shown, highly magnified, at fig. 1, *d*.

The newly hatched larva.—The larva when first hatched is delicate, white in color, sparsely hairy, and is about a millimeter long, being about six times as long as wide when contracted. It is widest at the head, which is light brown. The eyes are small and nearly black. The first thoracic segment is nearly as wide as the head, perceptibly darker than the remaining segments, which are clear white and less than four-fifths as wide as the head. The legs are long, particularly the thoracic ones.

The full-grown larva.—The full-grown larva or caterpillar is of nearly the same form as that of the Mediterranean flour moth, *Ephestia kuehniella* (see fig. 2.), and faintly marked individuals would easily be mistaken for that species. It differs chiefly in its smaller size, being a third smaller than the flour-moth larva, in its darker color, and in its more prominent piliferous dots, which, with the pink or flesh tints which are arranged longitudinally along the dorsum, give it a distinctly striated appearance.

DESCRIPTION.

The full-grown larva is cylindrical, about six times as long as wide, generally of similar form to *E. kuehniella*. Ground color dirty whitish, very pale greenish, or very light buff, with an overlay of rather dull pinkish tints arranged in more or less definite longitudinal rows on the dorsal surface. Surface very finely granulate. Head about half the greatest width of the body, ochraceous or cinnamon rufous in color, darkening toward the mouthparts. Thoracic plate (cervical shield) of similar form to that of *kuehniella* but faintly tinged with blackish anteriorly and much darker, nearly black posteriorly. Piliferous dots or warts, and particularly the other markings, nearly as in *kuehniella*, but all dots of darker color, nearly black, larger, and more conspicuous. Ventro-lateral and ventral rows quite conspicuous, the four pairs of rows presenting, with the banded pink coloring of the dorsal surface, a distinctly striated appearance. Posterior fold of abdominal segments not noticeably smaller than anterior.

Length, 9.5–12.5 mm.; width, 6.2 mm. In appearance more robust than *E. kuehniella* when contracted and when at rest, and more slender when extended. A larva 10 mm. in length will extend to 12.5 mm. and contract to 8.5 mm.

The larva is illustrated in figure 1 at *c*, about four times natural size, and that of *E. kuehniella* is reproduced in figure 2 for comparison.

The larva exhibits much the same variation in color as does that of *E. kuehniella*, the quality of food playing no perceptible part in regulating or even indicating the hue. The ground color ranges from whitish to yellowish and greenish, with flesh tints arranged longitudinally, somewhat like stripes, along the dorsal surface.

In some individuals the flesh tints are almost wanting; in others they are so marked as to give the impression of a body color of pink and even purplish. Individuals reared from the interior of English walnuts, where they were concealed from the light, were as a rule lighter in color than those that had fed, in a more exposed position, upon flaxseed, and the latter were also more strongly marked with flesh color.

The cocoon and pupa.—The cocoon of the fig moth varies according to its location. The specimens that "spun up" in corn meal and were covered with particles of the meal varied from 10 to 20 mm. in length, outside measurement, but were only about 6 mm. in length, inside measurements. Cocoons "spun up" without the covering measured from 10 to 12 mm. in length and were 3.5 mm. wide. Inside they are lined with exceedingly fine, delicate white silk.

The pupa, as would naturally be expected, resembles closely that of *E. kuehniella*, but is of a lighter color and smaller, measuring between 7 and 8 mm. in length, and is about four times as long as wide.

LITERATURE AND HISTORY OF THE SPECIES IN EUROPE.

This species was first described by Francis Walker in 1863,[1a] and later redescribed by Zeller in 1867,[2] from two examples from Cairo, Egypt, as *Ephestia cahiritella*. It was subsequently redescribed in 1875 by Barrett,[3] who called it *E. passulella* from its occurrence in the so-called Corinthian raisins or currants ("*Passulæ corinthiacæ*"). This is a fruit of a small variety or species of grape, in this country universally called "currants." To distinguish it from other species that infest dried fruits the writer suggested calling it, after the later Latin name, the dried-currant moth.

Walker and Zeller in their descriptions say nothing of the habits of this moth, and Barrett said only that it was "locally common in currant warehouses" in London and that it fed upon dried currants. He observed, however, that it had the singular hovering flight, common to the Indian-meal moth (*Plodia interpunctella*) and *Ephestia elutella*, that it was "exceedingly active and lively, flying freely in the afternoon," and that "the air often seemed alive with these insects." In 1882 William Buckler[4] made some study of the habits of the species, which he fed upon the "locust bean" of commerce, describing the eggs, larva, pupa, and cocoon. During the same year, and in the same periodical,[5] Mr. George T. Porritt published a supplementary note expressing the opinion that the species is double brooded, and mentioned dried figs as a food material. To this the same writer added the observation that the larvæ remained in their

[a] The small figures refer to corresponding figures in the bibliographical list, p. 39.

cocoons during the winter and changed to pupæ, without feeding, in the spring.[6] Again in this same publication Mr. Edw. A. Atmore[7] gave an interesting account of the occurrence of this species and *E. ficulella* in a cargo of "decorticated cotton cake" from Galveston, Tex. This cargo had become wet and heated on the voyage and when the ship arrived at King's Lynn, England, and the hatchways were opened, a cloud of the moths flew out, "settling on everything and everybody near." Owing to the superabundant heat induced by the wetting of the cakes the moths had issued prematurely. When exposed to the cold of February they were benumbed and fell upon their backs. In 1885 Mr. E. L. Ragonot[8] furnished some new localities for the species and in 1890 Mr. Richard South,[9] in a paper on British Lepidoptera, republished Barrett's description, bringing together the bibliography and known distribution with a plate figure of the adult. During 1891 Mr. W. T. Pearce[10] wrote a short note on this species, stating that "the larva forms silk-lined passages through dried currants and may be found in almost any case of them; there appears to be a constant succession of broods throughout the year." He also mentioned the occurrence of a small black ichneumon parasite. In 1895 Mr. Edward Meyrick, in his Handbook of British Lepidoptera,[12] furnished a brief description of the moth, with distribution.

HISTORY OF THE SPECIES IN AMERICA.

The first record of the injurious occurrence of this moth in American literature was made by the writer in 1897[13] and appeared in the form of a short preliminary paper entitled, "A storehouse moth new to the United States, with notes on other species." An account was given of the observed occurrences of the species in America, together with brief descriptive and other notes and illustration of the eggs, larva, moth, and wing venation.

The first recognition of the moth in this country, however, dates back to 1884, when, as previously stated, the species was observed in England in cotton cake from Galveston, Tex. Of course there is here the possibility that the cotton cake became infested en route, but it is more probable that the material was already infested before shipment.

When we consider the wide distribution and omnivorous habits of this species in America at the present time, there is little doubt that it was introduced many years before the first recorded date, 1884; and it also seems likely, considering its abundance, that it has to a certain extent replaced *Ephestia elutella* if we assume that the latter was introduced at a much earlier date, as seems probable.

During September and October, 1893, moths were issuing freely and flying about cases of cacao beans exhibited by Jamaica and Vene-

zuela at the Columbian Exposition, where the species was first observed by the writer. There were hundreds of bags and open boxes and jars of cacao beans exhibited by most of the tropical and semitropical countries, many of which were more or less affected by the larva of this insect. It seems probable that this species has been introduced wherever cacao-bean cultivation thrives and wherever chocolate is manufactured, judging by the fact that so many exhibits showed signs of infestation.

At the same exposition it was found to have bred in dried gallnuts, labeled "gobaishi," exhibited by Japan.

In October, 1895, a lot of flaxseed meal that was badly infested with the larva of this moth, was received from Calla, Ohio. The meal was transferred to a jar and as the larvæ worked toward the sides it could be seen that they were present in great numbers, and it was necessary to add fresh meal in order to keep them supplied with sufficient food. Long after the larvæ of *Plodia interpunctella*, which were present in vivaria under similar conditions, had for the most part left their food in search of places for pupation, these caterpillars were still active, although kept in a very cool room at an average temperature of about 60° F. Upon moving the jar an explanation of this was offered. The bottom and sides of the jar, a thick glass fruit "can" in this case, were quite warm.

In December of the same year specimens of this insect in different stages were received from the Atlanta exposition in cacao beans from Venezuela, South America, and from Jamaica and Trinidad, British West Indies, and in tonka beans (*Dipteryx odorata*) from Guayaquil, Ecuador. During this and following months in 1896 several pounds of English walnuts more or less affected by the larva were obtained by the writer from various local merchants and street venders. In some lots nearly every nut had been ruined by the caterpillars. Their presence is manifested by the lighter weight of the nut and its stem end usually shows a small hole or two that has been used either for entrance or exit, and a few particles of webbed-up excrement will sometimes be found accumulated at this point. If such a walnut be opened, its interior, if it be badly infested, will be found filled with larval excrement, the particles composing the mass being united by webbing.

The writer has also reared the species from pecan nuts and has seen specimens reared from peanuts.

Figs purchased of street venders in different parts of the city at about this time were found to be very generally affected by this species.

The following June (1896) the Bureau of Chemistry transmitted specimens of the larvæ in a sample of pearl hominy purchased in open market in this city. The larvæ were "spun up" in the same manner

as are those of *Ephestia kuehniella*, the cocoon thus formed looking much like that of the flour moth. June 6 the first moth issued, and at the same time larvæ were discovered at work in an open bottle of corn meal standing on the writer's office desk. The meal had been used for observations on other insects and it had not been necessary to keep it covered. A moth of this species had escaped from an open box of nuts, laid its eggs in the meal, and this was the result. Subsequently moths were reared in great numbers, this accidental evidence of the cereal-feeding habit of the species proving more satisfactory than a purely artificial experiment would have been.

During July a larva, from the same source as the ones found in the corn meal, was discovered at work in a small box of duplicate specimens of moths of its own species. It had ruined seven specimens by eating away their abdomens and in some cases a portion of the wings. In the rearing jars evidence of this same habit had previously been noticed.

Other stray larvæ were found breeding in the berries of asparagus, which they appeared to relish as much as any other food material. Moths also bred from stored corn at this time in two instances.

November 12, 1896, the late Dr. James Fletcher sent specimens of the larvæ breeding in linseed meal received from Montreal, Canada.

On June 2, 1898, Mr. J. L. Sheppard, Charleston, S. C., sent specimens of the larva in its webs in cleaned or white rice, with information that nothing injures the sale of their domestic rice as do these larvæ. During the previous year they appeared in rice toward the last of the summer, many of them at that time being quite large and measuring upward of half an inch in length.

September 21 of the same year Mr. Frank Bates, an entomologist, residing at South Braintree, Mass., wrote that the larvæ do much damage to chocolate unless great precautions are taken, and that he had known the owner of a chocolate company at Milton, Mass., to order several tons of chocolate shells, so-called, valued at about $200 a ton, to be thrown into the furnace and destroyed, as he would not risk any depreciation of his goods. He had occasionally seen "shells" in bulk at small grocery stores almost matted together by the silken threads thrown out by these larvæ, so that a mass as large as a man's head could be lifted from the barrel and the larvæ would be seen crawling out of the mass. "This," he writes, "gives us the evident warning never to purchase cocoa shells except those done up in pound cartons." Our correspondent stated that he never employed for his personal use any manufactured chocolate except that manufactured by one firm, which he knew to be of the best quality, since the owner did not permit any shells to be sold in bulk.

During 1907 Mr. Perry D. Preston, Isthmian Canal Commission, Canal Zone, Isthmus of Panama, wrote from Empire, sending speci-

mens of Spanish bean or chick-pea imported from Spain, where they are known as "garbanzos," showing injury by this species. November 23, Mr. P. J. Wester, Miami, Fla., sent larvæ in the seed of *Cecropia palmata*. From this lot the first larva transformed to pupa December 7, and the adult issued December 27, or in 20 days; this being an exceptionally long period for the pupal stage. An adult issued January 4, 1908. This sending is of peculiar interest inasmuch as it points to a possible wild food plant, and to the fact that in a tropical climate like that of Miami, Fla., the moths may issue throughout the winter. December 4, a larva of this species was received from an unknown locality in China in the fruit of the jujube tree (*Zizyphus jujuba*).

During 1908 this species was received in the larval condition in flour and meal from Sherman, Tex., sent by Mr. D. K. McMillan, and through the Bureau of Plant Industry in peanuts from Saigon, Cochin China.

In 1909 this insect was received from many sources. Larvæ were collected in a number of large cities and milling towns in Texas and Louisiana by Mr. McMillan. The records of the bureau also show that on June 15 it was concerned with other insects in damaging rice to the extent of many thousands of dollars a year at New Orleans, La. June 19 it was reported by Prof. Harper Dean as common in meal from San Antonio, Tex. June 21 it was received in flour from a mill in San Antonio, Tex. Later it was received in flour and other mill stuff from different mills in San Antonio and New Braunfels, Tex. It was present in cottonseed mills at Galveston, Tex., and in rice in a rice mill at Morse, La. In July it was collected by Mr. McMillan in flour at Fort Worth and Wichita Falls, Tex., in cottonseed meal from Guthrie, Okla., and in flour from Wichita, Kans., where it was troublesome in bakeries. Specimens were also received, July 19, from Hershey, Pa., where it was injurious to dried currants.

October 9 Mr. W. R. Beattie furnished specimens in seed peanuts from Africa. In November and December Mr. McMillan furnished larvæ in broken rice from Beaumont, Tex., in various dried seeds and grains from Houston, Tex., and from screenings taken from a rice mill at Lake Arthur, La.; in a lot of broken rice called "brewers' stock" the insect occurred in great numbers, badly infesting the material. In one case nearly 100 sacks of screenings in one mill were badly affected.[a]

The above records refer chiefly to the occurrence of this species in rice mills, although there are some records also of occurrence in flour mills, e. g., in Dallas and McKinney, Tex., and of injury to dried fruits, etc.

[a] In some of these cases other insects were present, such as the rust-red flour beetle (*Tribolium navale* Fab.) and the lesser grain borer (*Rhizopertha dominica* Fab.).

Beginning with October 14, 1909, the bureau received during the month, almost daily, samples of Smyrna figs infested by this species from New York City, Philadelphia, and Boston. These were furnished by the Bureau of Chemistry by request, and were in most cases in Smyrna figs seized by that bureau because of "worminess"[a] or because they consisted "in whole or in part of a filthy, decomposed, or putrid animal or vegetable substance, or any portion of an animal unfit for food." One sample of infested Cartrevas figs was received.

From the same source this insect was also received in shelled peanuts and dried apples from Boston, Mass.

During 1910 a milling company at Crowley, La., sent this larva in rice, bran, and cottonseed meal, with complaint that it occurred in immense numbers and apparently did trouble by working in the sacks. During November and December of that year samples of this insect and its work were received from Mr. E. G. Smyth, collected by him at Smyrna, Turkey in Asia.

During January and February, 1911, numbers of samples of figs were examined which showed the presence of this species either as dead larvæ or excreta. A few living larvæ were seen.

In writing of the occurrence of this species in Texas and Louisiana Mr. McMillan says that in his experience it is frequently found in mills, warehouses, dock sheds, feed stores, groceries, and other places where ground foodstuffs are kept. It was observed in small numbers in drug stores and in kitchen closets and cupboards. While the moths were seen in nearly all the flour mills visited in Texas, the larvæ were not found in excessive numbers, and the millers did not complain of serious trouble. Slight accumulations of webbed material had to be removed at times from some mill spouts, but no case has been reported of choking up as with *Ephestia kuehniella;* in fact few millers have made any observations upon this species or distinguished it from other flour and meal moths. He stated further:

> It seems to prefer the coarser and sweeter ground products to flour, and the moths are more frequently found in bran and middlings, and around the spouts carrying these materials, than associated with straight flour. Among substances most commonly infested may be listed cottonseed meal, rice bran and polish, mill chop and middlings, wheat flour and bran, corn meal and corn bran or hulls, oatmeal, flaxseed meal, and occasionally breakfast cereals in private houses and groceries.
>
> Larvæ have been less frequently seen than adults, though their webs in small masses mingled with food materials and excrement are often abundant when they have been allowed to accumulate undisturbed for some time. In a feed and grain warehouse at Galveston, Tex., the top and outside tiers of bags hold-

[a] In some instances a parasite, probably *Limnerium ephestiæ* Ashm., and a few specimens of other species of insects, accompanied the samples. Chief among these latter were the saw-toothed grain beetle (*Silvanus surinamensis* L.), one of the sap-beetles (*Carpophilus hemipterus* L.), a scavenger which attacks neglected fruits, two species of ants, and the mite *Carpoglyphus passularum* Hering.

ing rice bran were covered in places with a thin layer of webs and many cocoons were seen around the edges of sacks and in folds of the cloth. The larvæ had not penetrated more than half an inch into the contents. In a flour mill here several partly filled barrels of old corn bran had been infested for some time, and the surface material was covered by a layer of hulls and matted webs about 2 inches thick, beneath which the larvæ did not seem to penetrate. They were also found on bags of cottonseed meal and rice bran on one of the wharves and in the cracks between the planks at one of the docks at New Orleans, La., where they were feeding on the cottonseed meal held by cotton lint.

The adults have been frequently seen mating or at rest in any convenient position upon sacks and in other situations in mills and elsewhere. Adults at rest have the front edges of the wings curved slightly inward and the wings in general held closely around the body instead of spread slightly and flattened upon their resting place as with *Ephestia kuehniella* and especially *Plodia interpunctella.* The moth is rather slow in flight. It remains at rest practically continuously during the day unless disturbed, but has often been seen flying in dark parts of buildings and at evening.

LIST OF FOOD MATERIALS.

In time, as observers become familiarized with this moth, it will doubtless be found to have nearly the same omnivorous tastes as the Indian-meal moth. The following list of its observed food materials is appended:

Cacao beans or chocolate nuts (*Theobroma cacao*); prepared chocolate; tonka beans (*Dipteryx odorata*); English walnuts, or, more properly speaking, Persian walnuts (*Juglans regia*); pecans; peanuts or ground nuts (*Arachis hypogæa*); figs; chick-pea (*Cicer arietinum*); wheat flour; rice and rice preparations and bran; Indian corn and corn meal and other preparations; hominy; oatmeal; cotton seed and meal and cotton-oil cakes; asparagus berries; evaporated and dried apples; linseed or flaxseed meal; Corinthian currants (*Vitis corinthiacæ*); the seeds of *Zizyphus jujuba;* the fruit of *Cecropia palmata;* "locust beans" of commerce; wild gallnuts; and dried insects.

Taken all in all, it seemed at one time that it was as an enemy of chocolate that this species was most entitled to serious consideration.

Cacao beans are injured seriously. The beans are often badly damaged and webbed together with silk and covered with excrement and other detritus. Again, a bean may have no visible signs of insect work upon it other than the presence of a little hole, sometimes nearly closed with silk, but such infested seeds are invariably lighter in weight and when opened are found to be filled with more or less webbed-up excrementitious matter which can not be otherwise than deleterious when taken as food into the human system. Great quantities of cacao beans are consumed in the form of confectionery and in cake, ice cream, and soda water, and in the beverages called cocoa

and chocolate. Even if we could ignore the unwholesomeness of eating or drinking substances containing the ordure and dead bodies of insects, the thought of using such materials in our food and beverages is repulsive, and yet the writer was credibly informed in 1893 that infested cacao beans were used not only for such purposes, but that when infested they brought precisely the same price per pound as the clean article and were not considered by the manufacturers in any degree inferior for their uses.

The fresh beans have an agreeable, nutty, slightly bitter flavor, but insect-infested nuts are more bitter and sometimes have a decidedly disagreeable taste, and there is at least a suspicion that the bitterness of the cheaper forms of so-called pure chocolate, sold in compressed cakes and in powder form, may be due largely to the work of the Ephestia larvæ and the possible decomposition that would be induced from their attack.

It will be readily noticed by perusal of the earlier records of the occurrence of the fig moth in the United States that there was apparent fondness shown for material containing an abundance of oily matter, such as various nuts, cotton seed, flaxseed, and the products of Indian corn, in all of which it bred freely. It was a matter of some surprise, therefore, to find later that it bred quite as freely on rice, which contains little oily matter, as also to learn that it had already established itself as a rice pest in the Gulf States. Doubtless in time it will be found to feed upon most if not all of the cereals, if we except such as unhulled oats and rye, the hulls of which are difficult to penetrate unless first attacked by some other insect.

It is still early to predict the future of this moth as a pest in the United States. Perhaps in the course of time it may be introduced from the Gulf region northward, but in spite of appearances which indicate that it is perfectly capable of becoming exceedingly troublesome, it is doubtful if it will ever become so serious a pest as is the Mediterranean flour moth. It is practically established in the South, but its increase in the North is problematical.

Some remark should be made in regard to the injury accomplished by this insect to figs. The main injury is accomplished before the figs reach America, the principal damage being effected en route from the orchards to our American ports. Examination in this office of many samples of imported figs furnished by the Bureau of Chemistry seldom showed the larvæ or "worms" in any number and few were alive; but in badly infested samples the excreta were very much in evidence and it is due more to the presence of the excreta and "worm holes" than to the presence of the "worms" themselves that the figs are deemed unwholesome or, more technically, wormy, filthy, and unfit for human consumption. Samples of such infested figs are shown in Plate I.

Figs as prepared and exposed for sale in the Northern United States are seldom injured to any great extent after arrival. It is doubtful if a second generation is ever produced, except in useless material. There is, however, always the possibility that the larvæ which are brought over here in consignments of dried figs, fruits, and other dry vegetable products may the following spring infest other food products, such as cereals, nuts, the seeds of cotton, flax, and others, which may be stored in the same buildings.

INSPECTION OF SMYRNA FIGS IN THE BUREAU OF ENTOMOLOGY.

During the year 1909, from September to January, many samples of figs—243 to be exact—were examined in the Bureau of Chemistry. Small lots from these samples, containing in most cases a few dead insects and in many cases excreta, were referred to the Bureau of Entomology, but with such small lots it was not possible to get any very valuable data from an entomological standpoint. During 1910, however, examination was made of a fair lot of samples, 30 in all, some purchased in open market, some furnished by Mr. E. G. Smyth, who sent or brought them direct from Smyrna, Asia Minor, including both sterilized and unsterilized figs, and a lot of "tapnets" and other bagged figs from New York, as also some samples furnished by the Dried Fruit Association of New York City, and one particularly bad sample furnished by the Bureau of Chemistry. These were all carefully examined by the writer from the standpoint of actual injury by insects, and the following is his report and summary. This in turn is followed by a report made by the Bureau of Chemistry on the seizures of figs made in 1909 in New York City (see p. 28).

CHITTN. No. 588.

Packages of figs sold in Washington, D. C., labeled "Smyrna layer figs, Turkey brand, packed in Turkey, prepared with glucose, packed and guaranteed by Van Dyke & Catrevas, New York and Smyrna, Turkey, under U. S. A. Serial No. 14902."

Sample 1, purchased of a Greek fruit dealer, December 21, 1910, on being opened showed that the figs had evidently been washed. Of the 11 figs, which were all of fair flavor except for slight acidity, there was evidence of attack by a single larva of the fig moth, its work being apparent on 3 figs. One parasitic cocoon and a trace of excreta were present on the 3 figs which were not quite perfect.

Sample 2, from same Greek, December 5, 1910, showed no evidence of insect attack, but one fig was considerably soured.

Sample 3, from same Greek, December 5, 1910, contained a single dead larva.

Samples 4, 5, 6, 7, 8, 9, and 10, the last three examined in February, 1911, were perfectly sound as regards the presence of either insects or evidence of their work.

CHTTN. No. 1185. UNSTERILIZED SMYRNA FIGS.

Sample 11.—Sent by E. G. Smyth from Grand Hotel Huck, Smyrna (Asia Minor), labeled "Pulled figs, not sterilized, packed September 16, 1910." Packed tightly and carefully in a thick box 8½ inches long, 3½ inches wide, and 2 inches high. When received at Washington, D. C., November 5, 1910, one end of the packing box had become loose.

From the sides of this mass of figs, which came out entire, everything looked clean, but on removing and examining each individual fig—30 in all—every one contained more or less excreta, much of which, however, could be readily brushed off.

There was no evidence of living insects at this time or later, when examined March 8, 1911.

CHTTN. No. 1186. SMYRNA FIGS STERILIZED BY DRY HEAT (233° F.).

Sample 12.—Grand Hotel Huck, Smyrna (Asia Minor), labeled "Figs sterilized in oven by dry heat, September 20, 1910; time 20 minutes; average temperature 112° C. (233.5° F.); shipped October 14 by E. G. Smyth;" received in the Bureau of Entomology, Washington, D. C., November 5.

The figs were all separated and showed the effects of sterilization by dry heat in their bleached color. A careful but not microscopic examination was made of every fig, 40 in all, with the result that on looking over all of them a second time only one fig was found to be in any way unfit for human consumption. This single fig showed a hole on the side through which a larva had escaped, and the usual amount of excreta for one larva was contained therein.

CHTTN. No. 1195. LAYER FIGS SCALDED AT 212° F.

Sample 13.—Labeled by E. G. Smyth "Figs scalded in hot water at 100° C. (212° F.) for 16 seconds, water containing 2½ per cent salt and some glucose."

Careful examination in February, 1911, of this sample, which was packed under Mr. Smyth's direction, September 2, 1910, showed absolutely no signs of infestation by insects, but the figs were unpleasantly sticky and adhered to the box.

CHTTN. No. 1187. UNSTERILIZED PULLED SMYRNA FIGS.

Sample 14.—Grand Hotel Huck, Smyrna (Asia Minor), labeled by E. G. Smyth "Pulled figs, not sterilized, packed September 16, 1910;" received in the Bureau of Entomology, Washington, D. C., November 5. Oblong box, identical with No. 1185, as tightly closed as possible, containing 30 figs.

On opening this box on day of receipt 4 nearly grown larvæ were seen resting on one side between the layers of figs. Further search in taking the figs from the box and transferring them to a rearing

jar showed the presence of 10 dead larvæ in all. A very large percentage of the figs was so much tainted with the excreta that they were not edible and would not pass an ordinary examination.

CHTTN. No. 1188. FIGS STERILIZED BY IMMERSION AT 215.5° F.

Sample 15.—Labeled by E. G. Smyth "Pulled figs, immersed 10 seconds in water at 102° C. (215.5° F.) before being packed." Water contained 2½ per cent salt. Shipped from Smyrna, Asia Minor, September 16, 1910; arrived at Bureau of Entomology November 5, 1910.

The immersion seems to have been somewhat unsatisfactory, judging by this lot, in that out of 30 figs in all, 24 would readily pass muster, while the other 6 were "wormy." Unfortunately for the success of this experiment, 2 larvæ were found, one living and one apparently dying. The figs did not present a good appearance when received, being extremely moist and sticky.

CHTTN. No. 1189. FIGS STERILIZED BY WATER, 215.5° F.

Sample 16.—Labeled by E. G Smyth "Pulled figs" immersed 10 seconds in water at 102° C (215.5° F.) before being packed. The water contained 2½ per cent salt, evidently sea water. Shipped on Smyrna truck September 16, 1910; received at Washington, D. C., November 5, 1910.

The figs, though damp and moist, were practically uninfested. At one end a very slight indication of insect injury was observed. Number of figs 30; taste excellent, but stickiness rather undesirable. In this case, upon removing the cover the figs presented a beautiful appearance.

CHTTN. No. 1190. FIGS STERILIZED IN HOT WATER AT 212° F.

Sample 17.—A 5-pound lot of layer figs labeled "Figs scalded in hot water," at 100° C. (212° F.) for 10 seconds, water containing 2½ per cent salt, and some glucose, from Smyrna, Turkey in Asia, September 17, 1910; packed under observation of E. G. Smyth. Received December 17, and opened December 20, 1910, at Washington, D. C.

Careful examination of this lot of figs by the writer showed that about one dozen, chiefly from one end, had a more or less pronounced acid odor. In every case there was also more or less acid taste. Where the fig was dark from fungus infection the acid flavor was pronounced, especially to one who had eaten an entire fig. The writer and Mr. Smyth detected this more readily than several others. With the exception of the finding of a few badly spoiled figs, which might have been readily picked out by the consumer, and a single larva (which had very evidently crawled into a crack in the box), the process of sterilization was successful and had not caused souring. It had certainly entirely prevented infestation by the larvæ. This sample would pass as prime fruit.

CHTTN. NO. 1191. LOCOUM FIGS.

Sample 18.—A package of "Locoum" figs in a wooden box seized by the Bureau of Chemistry on account of the presence of "worms," was received at the Bureau of Entomology February 1, 1911, and carefully examined for insect injury.

Of the 75 figs examined, 20 showed more or less insect injury, but no insects whatever were present. Of this number the majority, to the number of 16, showed injury more or less plainly on the outside, some containing worm holes penetrating to the interior, others simply small holes which did not penetrate and which contained only slight excreta on the interior. Four figs only showed decided evidences of excreta in the interior. The remainder were sound so far as insect attack was concerned, but it was noticeable that 6 of these figs were badly soured.

To summarize, out of the entire 75, 10 figs were not edible—4 on account of insect excreta in the interior, 6 on account of sourness—while the remainder were not sufficiently injured to be rejected by the average consumer. Nevertheless, since the top layer was worst affected, the box when first opened presented a bad appearance. As usual, injury was most pronounced at one end, at the end where examination began.

CHTTN. NO. 1192. LOOSE FIGS STERILIZED IN STEAM CLOSET AT 239° F.

Sample 19.—A wooden box of loose figs sent by Mr. Smyth from Smyrna, October 6, 1910, sterilized in a steam closet at 115° C. (239° F.) for 10 minutes; examined in the Bureau of Entomology by the writer.

This package contained 75 figs, of which 59 were perfectly sound, showing no positive evidence of insect attack. One was sound but with slight excreta and with one dried pupal skin on the exterior; 11 were spoiled, mostly with excreta internally; 1 was spoiled with 1 dead and dry larva and excreta and another was spoiled with a wormhole and excreta internally; 2 otherwise badly spoiled figs had excreta internally.

CHTTN. NO. 1193. DUPLICATE OF NO. 1192, CONTAINING 60 FIGS; EXPOSURE 30 MINUTES.

Sample 20.—Of these 51 were sound, 6 showed excreta internally, while 3 were spoiled from other causes. The figs containing excreta in both lots were in most cases split, giving ready access to the insects.

INSPECTION OF SAMPLES OF FIGS FROM THE DRIED FRUIT ASSOCIATION.

CHITTN. No. 1194.

Sample 21.—In a lot of samples of figs labeled "rejected and ordered reexported or destroyed," submitted by Mr. L. B. Parsons, president of the Dried Fruit Association, New York City, and Mr. Davis, Bureau of Trade Relations, 507 Union Trust Building, and kindly furnished for examination to the writer in January, 1911, the following report is made:

Sample 22.—Labeled "C. A. A., 722 Laselle brand, fancy Locoum figs," packed in a box 7½ by 8½ inches and 2 inches deep. Five out of 25 of the figs of the upper layer, upon removal, showed slight evidence of excreta of the fig moth. A few particles, of course, could be seen on some of the other figs. No insects were found on this layer and no wormholes.

Sample 23.—Labeled "C. A., 36 Laselle brand, fancy Smyrna layer figs," showed on the upper layer 2 wormholes in one fig, 1 dead specimen of *Carpophilus hemipterus* L., and 1 living larva of *Silvanus surinamensis* L. No other infestation was apparent from this examination.

Both samples, judging from external layers, were otherwise in excellent condition.

Sample 24.—Labeled "London brand or extra choice natural fig for manufacturing." This contained evidences of attack by 3 larval fig moths.

Sample 25.—Labeled "Sterling brand or good average for manufacturing." This did not show evidence of insect attack by careful examination.

Sample 26—"*N. Y. 23,702.*"—A large box of figs bearing this number, submitted by the Bureau of Chemistry for examination, labeled "London layer figs, carefully selected," containing between 10 and 12 pounds, was received and examined February 13, 1911.

Without pulling all of the figs apart, a good estimate was given of their condition. There was external evidence of fig worms in the shape of large "wormholes," on 3 figs on the upper layer. At opposite ends on the lower layers injury was much more noticeable than on the upper layers—something unusual. At least 50 per cent of the figs contained more or less excreta, of which about 35 per cent contained a sufficient amount to cause their rejection by any fastidious would-be purchaser or consumer. Without opening all of the figs, there were estimated to be at least 30 larvæ or fig worms, all full grown and dead, with the exception of two which were living. The figs were, moreover, not as clean as desirable, containing small bits

of hair and of matting and some insect webbing. Some figs were also badly soured, some were lightly covered with dirt and mold, and altogether the boxful presented a filthy appearance.

CHTTN. No. 1196. MIXED FIGS STERILIZED BY DRY HEAT AT 190.5° F.

Sample 27.—Labeled by E. G. Smyth "Figs sterilized in oven by dry heat September 21, 1910, subjected to 5 minutes average temperature 88° C. (190½° F.), Smyrna, Turkey in Asia." Received at Washington, D. C., November 5, 1910.

Examination showed absolute freedom from insects and even from excreta. Kept in nearly air-tight jars, the figs retained their flavor without acidity until March 8, 1911, when the record was closed. The flavor of these figs, although they were rather dry, was better than that of some of the best layer figs sterilized by hot water.

CHTTN. No. 1197. LOCOUM FIGS STERILIZED BY DRY HEAT AT 225° F.

Sample 28.—Labeled "Grand Hotel Huck. Locoum figs sterilized in oven by dry heat, September 20, 1910; 15 minutes, average temperature 107° C. (225° F.), packed by E. G. Smyth," examined March 8, 1911; contents, 24 figs.

Six figs showed excreta mostly in the "eye" end and with some slight amount of loose excreta, which was removed almost immediately upon shaking. The remainder of the figs was sound, and although kept in a dry heated atmosphere they were of excellent flavor, although somewhat dry.

N. Y. 23782, 23139, 22758 AND 22760, PORTUGAL TAPNETS.

Samples Nos. 29, 30, 31.—From the Bureau of Chemistry were received the above samples of Portugal "tapnets" or bagged figs withheld because of infestation by what may be properly called the fig mite (*Carpoglyphus passularum* Hering). The species was identified by Mr. Nathan Banks, of this bureau, who stated that it is a common species found on dried fruit the world over, that it is not the cause of the souring of the figs, and in no way injurious to the consumer. There can be no doubt that this decision gives these forms of mites the same status as those found in other stored foods such as flour, meal, and other cereals and in old sugar and cheese. In fact, the latter commodity is seldom free from these microscopic creatures, which have never been held to be in any way injurious to human life. No less than 516 bags of such figs were seized and held in New York City, but were finally released.

SUMMARY.

Sample.	Lot number.	Number of insects dead.	Number of insects living.	Percentage of excreta.	Percentage of infestation.	Source of samples.
1	588	1	0	27	10	Layer figs purchased in open market.
2	588	0	0	0	0	Do.
3	588	1	0	0	10	Do.
4	588	0	0	0	0	Do.
5	588	0	0	0	0	Do.
6	588	0	0	0	0	Do.
7	588	0	0	0	0	Do.
8	588	0	0	0	0	Do.
9	588	0	0	0	0	Do.
10	588	0	0	0	0	Do.
11	1185	0	0	100	25	Unsterilized "pulled" figs.
12	1186	0	0	2.5	2.5	"Locoum;" sterilized by dry heat, 233.5° F.; 20 minutes.
13	1195	0	0	0	0	Sterilized by hot water, 212° F.; 10 seconds.
14	1187	10	0	75	25	Unsterilized Smyrna figs.
15	1188	2	0	20	.....	Sterilized by immersion at 215.50° F.; 10 seconds.
16	1189	0	0	0	0	Sterilized as in No. 15.
17	1190	1	0	0	1–	"Locoum;" sterilized by immersion at 212° F.; 10 seconds.
18	1191	0	0	26	26	Condemned for "worminess."
19	1192	2	0	21	10	Sterilized at 239° F. steam; 10 minutes.
20	1193	0	0	10	5	Do.
21	1194	0	0	Slight.	0	Condemned by Bureau of Chemistry.
22	1194	1	1	0	0	Do.
23	1194	3	0	Slight.	5	Do.
24	1194	0	0	0	0	Do.
25	N. Y., 23, 702.	28	2	50	25	Do.
26	1196	0	0	0	0	Sterilized by dry heat; 190.5° F.; 5 minutes.
27	1197	0	0	25	(a)	Sterilized by dry heat; 225° F.; 15 minutes.
28	N. Y., 23, 782; 23, 139; 22, 758; 22, 760.	(b)	(b)	.....	(a)	Portugal tapnets withheld by Bureau of Chemistry.
29	.....	(b)	(b)	25	(a)	Do.
30	.....	(b)	(b)	25	(a)	Do.

a All edible. b Microscopic mites.

In the above summary it should be noted that the percentage of excreta is no indication of what may be considered the percentage of infestation, since the excreta become loose and adhere slightly to uninfested figs. It will be noted that samples 1 to 10, purchased in open market, were free from insect injury except in two cases.

In the case of sterilized figs there was, as a rule, a considerable difference from the unsterilized figs from the same source. It is obvious, as Mr. Smyth informs me, that the heat in many cases was not applied sufficiently high, and was not continued long enough to entirely penetrate such large masses as 5 or 6 pounds of layer figs. Of the 30 samples examined, Nos. 1 and 3, each containing 10 per cent of infestation, Nos. 11, 14, and 25, each containing 25 per cent of infestation, and No. 18, containing 26 per cent, not one could be pronounced inedible, and it will be noticed that Nos. 27 to 30, although containing a considerable percentage of excreta and microscopic mites, were also considered edible. No. 1185 would be pronounced unfit for human food on casual examination, but in reality,

when shaken and slightly brushed, these figs came out in first-class condition and were pronounced of exceptionally fine flavor.

In no case could it be positively said that the heating processes, whether dry, wet, or by steam methods, had caused souring, although one case of figs which had been sterilized was examined and some slight acidity noticed on the figs, probably existent before treatment by heat.

AVERAGE INFESTATION OF SMYRNA FIGS ENTERING THE PORT OF NEW YORK.

	Per cent.
Average of 4 samples arriving during September	24.05
Average of 54 samples arriving during October	25.14
Average of 115 samples arriving during November	27.36
Average of 51 samples arriving during December	30.99
Average of 19 samples arriving during January	38.17

The above averages include injury to figs attributed to the larvæ of *Ephestia cautella*, but more particularly to their excreta, and are taken from records carefully computed in 1909 and 1910 in the Bureau of Chemistry, and submitted by Dr. F. L. Dunlap. As previously stated, a total of 243 samples in all was examined in that bureau.

These figures show what had previously been deduced by the writer from experience with other related species, namely, that the early figs are least infested and that the latest figs introduced into this country from abroad are more infested than the earlier ones.

LIFE-HISTORY NOTES ON THE FIG MOTH.

The fig moth in America, so far as we can at present learn, is practically confined as a pest to rice, flour, and other mills, and to warehouses and storage rooms, and the notes which have been made in regard to its life history are solely from the standpoint of its life as an indoor pest. The results of experiments show very little difference between the life history of the fig moth and that of the Indian-meal moth—very similar species, nearly identical in size and habits.

OVIPOSITION.

All of the eggs that have come under observation were deposited singly and loosely, being readily detached by a slight touch.

Three females were selected for the determination of the number of eggs that might be laid. The first, although full-bodied, had evidently already begun egg-laying, since she yielded only 132 eggs by oviposition and dissection. The second deposited, in round numbers, 165 eggs and upon dissection yielded 115 more and contained

135 undeveloped eggs, a total of 415. The third, which was taken in copula at the time, laid by actual count 357 eggs, and 7 fully developed eggs were added by dissection, in all 364.

Eggs that were laid during the night of July 13 were found to have hatched on the morning of July 17, giving a period for the egg state of not more than 3½ days. The temperature of the room in which this experiment was conducted at this time ranged from 83° to 88° F., during the last night running down to 73° F.

THE TRANSFORMATION TO PUPA.

The larva or caterpiller, when it has attained maturity, has the same habits as those of *E. kuehniella* and *Plodia interpunctella*, of crawling about for a long time in search of a place for transformation to pupa. If anything it spins more web than even Plodia at this time.

Several full-grown caterpillers were isolated for observation of the period of pupation with the unlooked-for result that several individuals transformed to pupa during the daytime. One of these transformed at 1 p. m. and another at 4 p. m., July 13, a third at 8 a. m. the following day, and a fourth at 2 p m.

1. Pupated July 13, 4 p. m.; adult found July 22, 3 p. m.; 9 days.
2. Pupa found July 14, 8 a. m.; adult found July 22, 3 p. m.; 8+ days.
3. Pupated July 14, 8 a. m.; adult found July 22, 3 p. m.; 8+ days.
4. Pupated July 14, after 5 p. m.; adult found July 23, 9 a. m.; 8½ days.
5. Pupated July 15, about 5 a. m.; adult found July 24, 8.30 a. m.; 9 days.

The average temperature was about 83° F.

Other individuals that were under observation transformed as follows:

No. 6, in 16 days in early May; No. 7, in 24 days in October, cool weather; No. 8, in November, warmer weather, 19 days.

We thus have a pupal period of from about 8 days to 24 days.

July 14, at 8 a. m., a pupa was noticed in the act of shedding its larval skin. By a few peculiar movements the skin was worked farther and farther down until the abdomen was entirely exposed. The entire operation under favorable conditions would not consume more than about 3 or 4 minutes, judging from the rapidity with which the abdominal segments were freed.

THE LIFE CYCLE.

A number of moths was confined with flaxseed meal April 14 and the first adult was found to have emerged June 1, or in 48 days from the presumptive time of the deposition of the first eggs. A week elapsed before the appearance of another moth, when 8 issued.

Moths were reared from corn meal as follows: Parents confined in a jar June 23; larvæ began leaving the meal July 20; new brood began to issue July 29, or in 36 days from the time the eggs were sup-

posedly laid. The temperature during this period had been by no means as high as in the minimum-period experiments with *Plodia interpunctella*, but during the last 2 weeks the thermometer had registered above 80° F. most of the time, ranging from 73° to 89°, with an average of about 82° F.

From the foregoing it will be seen that the minimum period of the life cycle in midsummer in the Middle Atlantic region of the United States is about 5 weeks and the periods in late autumn and spring 7 weeks. The species hibernates in the larval and the moth states and does not breed out to any extent during the colder months, but occasionally adults emerge in superheated rooms.

The egg state, it has been shown, may last no longer than 3½ days, although in cool weather this period may be protracted into 2 weeks. Deducting the minimum periods of egg and pupa from the 36 days covered by the entire life cycle in midsummer we would have left 13 days for the midsummer larval period. From this may be deduced the following: Egg period, 3½ to 14 days; larval period, 13 to 30 days; pupal period, 8½ to 24 days; life cycle, 36 to 48 days.

The period of the hibernating larva has not been observed, but from analogy it appears certain that this period will vary greatly, some individuals remaining as larvæ months longer than others, irrespective of heat, moisture, or other conditions.

If the insect should happen to be breeding in a large mass of rice or corn meal, it could develop at the same rate as the Mediterranean flour moth, producing as many as six generations per annum, but in figs, walnuts, and similar material, where no great amount of artificial heat could be engendered, no more than four generations are probably produced in the average storehouse temperature. In our colder climates, where the species might be temporarily introduced, perhaps no more than three, or even two, generations would be produced.

NATURAL ENEMIES.

Two species of parasites which have received previous notice[13] have been observed by the writer, in addition to a mite, preying upon this moth. Undoubtedly it has many other natural enemies.

Hadrobracon hebetor Say.—On many occasions the little braconid *Hadrobracon hebetor* Say, which is now a well-known parasite of *Ephestia kuehniella* and *Plodia interpunctella*, was reared from the larvæ of this moth in walnuts, cacao beans, and other food materials. It was found in abundance at Smyrna attacking its host in figs. This species is illustrated in figure 3.

Omorga frumentaria Rond. (fig. 4.), also a parasite of grain and meal-feeding moths, was reared at this office from *E. cautella*. In one instance where the parasite was found in large numbers in a jar

in which its host was breeding, the eggs of the parasite must have been thrust through the cloth covering of the jar, which contained only fresh material, and there had been no exposure of its contents and no other manner for the parasites to have obtained access to this jar. Particulars in regard to this are furnished in an early publication of this bureau.[a]

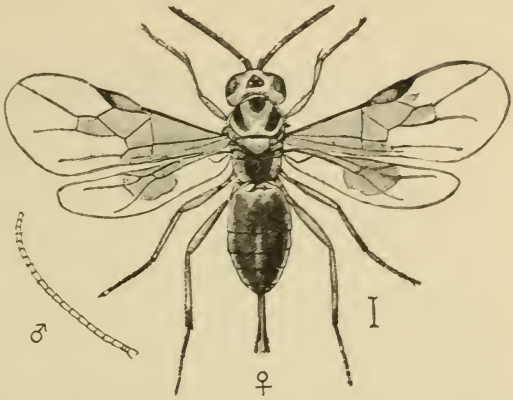

FIG. 3.—*Hadrobracon hebetor*, a parasite of the fig moth: Adult female; antenna of male at left. Greatly enlarged. (Author's illustration.)

Pediculoides ventricosus Newp.—The third count of eggs laid by this moth, related on a preceding page, was productive of an unexpected result in establishing the mite *Pediculoides ventricosus* as an egg parasite. In a glass tube in which a copulating pair of the moths

FIG. 4.—*Omorga frumentaria*, a parasite of the fig moth. Lateral view. Greatly enlarged. (Original.)

was confined, about a score of mites of this species was found, some attacking and sucking out the contents of the eggs, while numer-

[a] Bul. 8, n. s., Bureau of Entomology, U. S. Dept. Agriculture, p. 41.

ous moth eggshells and the full, rounded abdomens of all but one or two of the mites attested to their having made similar meals. Their bodies were almost identical in size with the eggs, from which they were only distinguished with a lens, and it is fairly certain that they were the progeny of a single adult that might have become attached to one or the other of the parent moths.

METHODS OF CONTROL.

The methods for controlling the fig moth in its occurrence in flour mills are the same as advised for the eradication of the Mediterranean flour moth, in which case we depend chiefly upon hydrocyanic-acid gas. In the case of smaller inclosures, where bisulphid of carbon is generally preferred, this can be used more readily and with about the same effect.

Preliminary work has been done in the fumigation of rice mills infested by the fig moth and other species of insects, which indicates that, owing to the more open structures where rice milling is in operation and the difficulty of closing the many apertures in these mills, fumigation is not always practicable.

A small series of useful experiments was recently conducted by Mr. D. K. McMillan and by Mr. M. M. High, while working under the writer's direction in Texas in the fumigation of rice mills.

Both hydrocyanic-acid gas and bisulphid of carbon were successfully employed after the mills or portions of them had been made as tight as could be done economically.

Carbon bisulphid was used upon adults and larvæ, chiefly of beetles, in rice bran and other materials in tight flour barrels at the rate of 5 pounds to 1,000 cubic feet of air space and 10 pounds to 1,000 cubic feet, each for 12 hours and 24 hours. Adults were killed in all four cases and larvæ in all cases except with the 5 pounds for 12 hours, where some insects crawled up to the top of the barrel and did not get the effect of the gas.

In fumigating mills at Fort Worth and at Dallas, Tex., *Ephestia cautella* occurred in each mill in small numbers.

Cyanid of potash was used in three mills at the rate of 10 ounces to 1,000 cubic feet as the weakest dosage. Adults were all killed and no living larvæ were to be found after careful search and thorough airing of material.

In a series of experiments in a fumigating room at Beaumont, Tex., the species occurred in sacks of rice bran and polished rice. With the dosage of 10 ounces of cyanid of soda to 1,000 cubic feet for 12 hours, adults and larvæ of this species were all killed and consequently with heavier dosages for a longer time.

The effect of cyanid upon the eggs could not be observed, owing to inability to find them.

Pile of Figs in Fig Depot—One of the Primary Places of Infestation. (Original.)

Directions for fumigating mills and other structures by the hydrocyanic-acid gas process are furnished in Circular No. 112 of the Bureau of Entomology, and instructions for the use of bisulphid of carbon as a fumigant are discussed in Farmers' Bulletin No. 145, both of which publications may be obtained on application to the Secretary of Agriculture.

While fumigation is not at present practicable in most of the "khans" of the fig-packing companies of Smyrna because of the impossibility of making them sufficiently tight for the purpose, there are still chances of ultimate success. For the perfect success of any form of fumigation of insects affecting stored products it is highly desirable that the buildings or other inclosures in which the material is stored be made perfectly air-tight. Under these conditions the minimum amount of bisulphid of carbon or other fumigant and the minimum exposure can be employed. Whatever fumigant is used, at least 24 hours' exposure is desirable, and in many cases 48 hours—particularly if the buildings are not quite air-tight—are necessary, especially in comparatively low temperatures. In preparing this paper for publication it occurred to the writer that perhaps, everything considered, the most simple means of fumigating, that is, with bisulphid of carbon, would be the best for treatment of fig-packing houses. The writer has exchanged opinions on this topic with three fig experts and as many entomologists, and they have all agreed that this should be a good method if employed by erecting special fumigating houses, to be made air-tight and placed at some distance, say, about 25 yards, from the main building. While it would be better to have these buildings constructed of concrete, they can be built of wood and lined both inside and out with stucco or cement. This would not only render them more nearly air-tight, but would, moreover, serve as an additional precaution against fire. It remains to be determined what amount of bisulphid of carbon would be the best for use in such buildings.

Efforts have been made to free the figs of "worms" by vacuum treatment, but with indifferent success. With layer figs in boxes it is not practicable.

We must, therefore, look for preventives and other more or less direct remedies. From the report on this insect made by Mr. E. G. Smyth, entomological assistant, engaged in stored-product insect investigations from August to November, 1910, in Smyrna, Turkey in Asia, the followng lines of treatment are suggested:

PREVENTIVES.

The principal time of infestation is while the figs are on the ground drying in the sun, and later, when piled in the fig depots (Pl. II), before shipment to Smyrna from the interior, where the figs are

chiefly grown; but the original infestation is due to carelessness in permitting the unmarketable figs of the June crop to remain in the field and serve as a breeding place for the pest. If this source of infestation could be removed by the complete destruction of the June crop, it seems probable, from present knowledge of the insect's habits, that in the course of time injury by this moth could be reduced to a minimum, since other opportunities for infestation are slight and not worthy of consideration. The framing of a regulation for the destruction of the June fig crop is advisable, and its enforcement should be attempted. In case of failure in the enforcement of such a regulation, the next step would be to protect the figs at night, while they are drying on the frames called "serghi," with a covering of cloth of a mesh sufficiently fine or of proper texture to prevent oviposition. This should be followed by the exclusion of the moths from the fig depots, where figs are heaped in piles, as shown in Plate II, by closely screening the doors, windows, and other openings, so as to make them moth-proof. After the figs are placed in goat's-hair bags infestation from this point onward practically ceases, so far as egg laying is concerned.

The pernicious practice of some growers and middlemen, of holding figs in the interior, could be stopped by stringent action by those most interested, and thus another cause of infestation would be eliminated.

HEAT AS A REMEDY.

The impracticability of other direct methods of treatment led to experiment with the simplest means of destruction of insects in stored products, viz, the application of heat, by steam, hot water, and hot air. Preliminary experiments were made along this line and should be continued by the packers to ascertain the length of time in different temperatures, pressures, and exposures to produce the best effect.

Figs scalded in early September had not shown indication of souring to late in December, while if exposed too long at the boiling point figs, it is claimed, acidify. It would seem that boiling is one of the best direct remedies that could be used, since a large proportion of the packers boil the figs intended for their own consumption, thus destroying between 80 and 100 per cent of the "worms" without additional expense in manipulation. By the use of dry heat the loss of time incident to the employment of the wet method, for drying after treatment, is eliminated, and there is less tendency to souring. Furthermore, the color, texture, and appearance are less affected when dry heat is employed. Already an experimental plant for the application of dry heat, called "sterilization," has been installed in a large "khan" of Smyrna, and admirable success has been obtained in the destruction of the fig "worms." The dry process, however, possesses

a disadvantage in that it does not remove filth and possible germs on the figs as in the case of boiling.

Progressive packers are willing to install a system of sterilization, providing that such be ordered by the Turkish Government and imposed equally upon all packers.

The value of the insect enemies of the fig moth as a factor in the control of the insect in figs imported from Smyrna is doubtful, since, although as many as 50 per cent of the larvæ may be parasitized, this does not prevent the larvæ from working in the figs until maturity.

METHODS OF PACKING FIGS AS A PROTECTION AGAINST INSECT ATTACK.

The following notes have been made in the course of the examination, during the winter of 1910–11, of figs packed according to different processes.

All in all, the figs purchased in the open market, packed in small boxes, were less infested than those packed in the large 5-crown or 6-crown boxes shipped from Smyrna direct. The worst-infested figs examined were the string figs, which are, moreover, very dry and inferior in appearance. (See Plate III.) They make particularly easy the entrance of insects from the time they are shipped until the time they are purchased by the consumer, especially when kept in a warm temperature, as is frequently the case. After a while they lose much of the characteristic fig flavor.

The figs packed in layers (Pl. III) and sterilized by immersion in hot water, especially if they are submitted to a temperature of 100° C. or a little above, equivalent to 212° F., for a sufficient length of time to kill all the insects, become sticky and adhere so tightly in some cases that it is with difficulty that they can be removed from the boxes; and, moreover, the individual figs become agglutinated, so that in separating them they tear in the middle and do not separate properly.

The "Locoum" and pulled figs, everything considered, especially where subjected to dry heat, are not, as a rule, quite so much subject to damage as are the layer figs, and, moreover, keep their flavor decidedly better.

Samples of the best layer figs which had been treated by hot water were tested in comparison with "Locoum" figs of apparently not so good quality, and out of 14 persons who tested these for flavor 13 were decidedly in favor of the "Locoum" and pulled figs as possessing the best flavor. Only one person was undecided. Enough glucose is used in the layer figs which were treated with hot water to impart to these a somewhat sickeningly sweet taste. A little more glucose would give them the flavor of a confection rather than that of a fruit.

EXPERIMENTS WITH FUMIGANTS AT A HIGH TEMPERATURE.

[By F. H. Chittenden and Thos. H. Jones.]

On May 18, 1911, the first good opportunity to test one of the fumigating gases against "worms" in figs was afforded. The desire was to have a high temperature, similar to that of Smyrna, and to make a test to determine if the insects could be destroyed at a profit in a short exposure. These experiments were conducted at Washington, D. C.

BISULPHID OF CARBON.

Since the majority of the fig-moth larvæ were dead and had been replaced in many instances by the Indian-meal moth (*Plodia interpunctella* Hübn.) during spring, figs infested by this latter species were used. The bisulphid of carbon was used at the rate of 1½ pounds to 1,000 cubic feet of air space, and the figs were placed in a specially prepared and very nearly air-tight fumigating box at 4.30 p. m. At this time the temperature was 90° F. When removed 24 hours later the temperature was exactly 100° F. The mean temperature was estimated at 96° F.

The figs were very thoroughly infested with the Indian-meal moth, there being an abundance of moths and larvæ. All were dead when examined on the morning of May 20. It is therefore safe to say that the fig moth can be destroyed in figs in an inclosure made sufficiently air tight, in a temperature between 90° and 100° F., which is apt to be encountered at Smyrna, and in a building especially constructed for this purpose, using 1½ pounds of bisulphid of carbon to 1,000 cubic feet of air space. There is no necessity for a longer exposure if the building is nearly air-tight, as in this case. The odor of bisulphid of carbon was quite perceptible when the insects were removed from the fumigatorium and was even perceptible in another room, to which the insects were removed, when opened the next morning. Up to June 3 no evidence of eggs hatching could be observed. The mass of figs fumigated was very carefully examined and no trace of young larvæ or eggs could be found. Eggshells, however, were seen and one nearly mature larva was still living, being incased in an unusually strong, somewhat leathery cocoon, placed tightly between two figs. With the amount of figs used in the experiment, this might be considered a perfect fumigation, since a single moth could not procreate and reproduce its kind.

It should be said that the Indian-meal moth (*Plodia interpunctella* Hübn.) is of about the same size as the fig moth in all its stages.[a] Therefore there would be practically no difference in the resistant power of the two species against any gas which might be employed.

[a] It has already been recorded that these two species have been observed *in coitu*, but the resulting eggs were not fertile.

FIG. 1.—FIGS PACKED BY STRING METHOD. REDUCED. (ORIGINAL.)

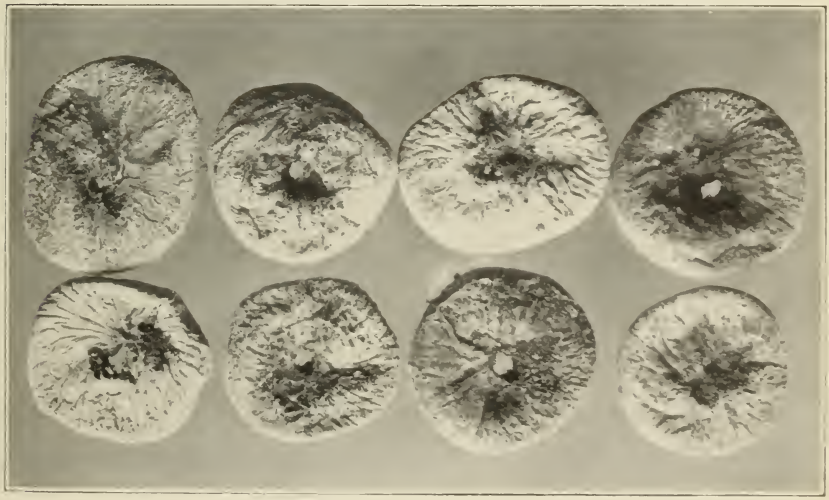

FIG. 2.—SOME OF SAME FIGS AS SHOWN ABOVE, TO ILLUSTRATE LARVAL INFESTATION. REDUCED. (ORIGINAL.)

PACKAGE OF SMYRNA FIGS PACKED IN TURKEY FOR AMERICAN TRADE, ACCORDING TO LAYER METHOD. (ORIGINAL.)

The fig moths, as has been stated in other portions of this bulletin, usually soon die out in America and are replaced in this country in the same material by the Indian-meal moth, which is more hardy and more nearly omnivorous.

HYDROCYANIC-ACID GAS.

Experiment No. 1.—June 23, at 4.05 p m., in a recorded temperature of 94° an experiment was made in the hope that the temperature would continue or increase, as frequently happens in the District of Columbia. In this experiment, which was conducted under the writers' personal supervision, Messrs. Duckett and O'Neill assisted. June 24, Mr. O'Neill made count of the insects after removal from the fumigator at 4.05 p. m. It will be seen that this was the usual 24-hour exposure. The proportions used were 6 ounces of sodium cyanid and 6 ounces of sulphuric acid to 1,000 cubic feet of air space. Owing to atmospheric conditions probably the exact temperatures and other conditions were not recorded, but the minimum was not lower than 80°, which would give a mean temperature of about 85°F. This experiment was conducted chiefly for the purpose of testing the results on the Indian-meal moth (*Plodia interpunctella*). Large numbers of these were in dried figs, packed as closely as possible. The result was that only 60 per cent were killed, showing that a relatively heavier dosage is necessary to kill this insect than is the case with bisulphid of carbon.[a]

Experiment No. 2.—Owing to the failure of the first hydrocyanic-acid gas fumigation experiment, undertaken June 23, a second experiment was found necessary. This was started at 3.45 p. m., June 27, and the same formula, 10 ounces of potassium cyanid and 10 ounces of sulphuric acid to 1,000 cubic feet, was used. The temperature during this period was 92° at the beginning, the lowest temperature recorded, between 6 and 8, being 80°, when the fumigation was completed. The mean temperature was about 85° F. Exposure was as before, exactly 24 hours being the time. The Indian-meal moth larvæ and adults in figs were all killed. The same was true of their occurrence in meal. The granary weevil was completely destroyed, and the same is also true of the lesser grain borer and the saw-toothed grain beetle. Only one species of insect survived: Four living adults of the *Tribolium confusum*, the confused flour beetle, in meal were not killed. It would be difficult to determine the percentage in this case.[b]

[a] Of other insects treated at this time, specimens of the lesser grain borer (*Rhizopertha dominica* Fab.) were all destroyed, furnishing additional testimony of the weak resistant power of this species to both gases.

[b] The larvæ and moths of the Mediterranean flour moth (*Ephestia kuehniella* Zell.) were also all killed, and the same was the case with the Indian-meal moth in meal. The saw-toothed grain beetles (*Silvanus surinamensis* L.) were all destroyed, but of the granary weevil (*Calandra granaria* L.) only 82.5 per cent were destroyed. In the case of the rust-red flour beetle (*Tribolium navale* Fab.) three larvæ were living. The four-spotted bean weevil (*Bruchus* [*Pachymerus*] *quadrimaculatus* Fab.) was destroyed.

SUMMARY.

To summarize the measures for the eradication of the fig moth in imported figs we may reduce them to the following methods of prevention and destruction:

(1) Prompt disposal or destruction of the useless June fig crop.

(2) Covering the figs at night while on the "serghi."

(3) Closely screening the fig "depots" in the interior.

(4) Prompt delivery of the figs to the "khans" after gathering.

(5) Destruction of the "worms" in the "khans" by "sterilization," i. e., by hot water, dry heat, or steam.

(6) Fumigation by means of carbon bisulphid in special fumigation structures, made as nearly gas-tight as possible.

(7) Fumigation by means of hydrocyanic-acid gas.

(8) Construction of the "khans" in the future so that they can be made gas-tight for the purpose of fumigating.

(9) Enactment of special regulations or legislation to secure the enforcement of the suggestions made.

(10) Clean methods of handling and storing at all times and in all places.

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REPORT ON THE FIG MOTH IN SMYRNA.

By E. G. Smyth, *Entomological Assistant.*

In accordance with orders received from the Secretary of Agriculture, contained in a letter of authority dated July 1, 1910, and under specific instructions from Dr. F. H. Chittenden, contained in a letter of June 30, the writer sailed from New York on July 9 for Smyrna, Turkey in Asia, to investigate the problem of eliminating the fig moth (*Ephestia cautella* Walk.) and other insects injurious to dried figs.

SOURCES OF INFESTATION.

As in the solution of all similar problems of how to avoid injury from insect attack, before definite remedies could be prescribed it was necessary to determine the exact source of infestation. There are seven distinct periods in the preparation of Smyrna figs for market, before their receipt at New York, when infestation by moths is possible: (1) While the fruit is on the tree; (2) while drying on the ground; (3) in the fig "depots" of interior Asia Minor; (4) in the freight cars en route to Smyrna; (5) in the bazaars in Smyrna; (6) in the packing houses or "khans"[a] of Smyrna; and (7) in the steamers during shipment to America. All previously noted habits of the same moth in this country, where it occurs only in buildings or places where dried fruits or food materials are stored, pointed to the packing houses as the most probable source of infestation, it being a matter of common knowledge that in them conditions of uncleanliness are so bad that the moths, if once established, would breed generation after generation unmolested.

When the writer reached Smyrna, August 5, it was found that the fig export season had scarcely begun and figs were not yet arriving from the villages, so the interior of Asia Minor was visited Half of the month of August was spent in the Meander Valley (Pl. V, fig. 2), which furnishes about 90 per cent of the dried figs of Smyrna, and in immediate proximity to the trees, where every condition surrounding the maturing and dropping of the fruit could be noted.

[a] A Turkish and Syrian word—a caravansary or unfurnished inn; used in Smyrna to designate a packing house, because caravansaries are often used for fig packing.

OCCURRENCE OF LARVÆ IN THE ORCHARD.

If the larvæ, or "worms," come from the orchard, as held by the packers in Smyrna, and are in the figs when gathered, the same degree of infestation should be found on the ripening fruit on the tree as in the dried fruit in the market, which is seldom less than 15 per cent and often more than 50 per cent. But this is not the case. On rare occasions only were larvæ found in the ripe fruit on the tree.

In an orchard at Kara Bounar, August 18, many figs were picked from the trees and broken open, and a few found to contain young larvæ. Figs were ripening in numbers and shriveling on the trees, and some had dropped and been gathered and spread on "serghi"[a] at one side of the orchard to dry. A small percentage of these was also found infested. The larvæ were quite young, most of them less than two weeks old. Their presence was usually indicated by a silk webbing at the eye of the fig. In no case was the skin of the fig injured by the larva, nor was there other evidence of its presence within the fig.

In an orchard at Nazli many figs were broken open from the trees, but very few were found wormy. Those placed in jars, however, later turned out to be often quite wormy, as though eggs or very young larvæ had been present in them when they were picked. Larvæ found were of the usual pink color, and occurred, as a rule, one, and very seldom more than two, in a fig.

A smaller larva, the young of a nitidulid beetle, *Carpophilus hemipterus* L., sometimes occurred in small colonies of from 3 to 7 individuals at the open or eye end of figs on the trees or drying on the "serghi." These occurred usually in split or injured figs, and their presence never accompanied that of Ephestia larvæ in a fig.

Repeated attempts to find larvæ in figs on the trees in the large orchards at Tchifte Kaive were unsuccessful. The conclusion was that, while figs are sometimes attacked by the larvæ of the fig moth before they fall from the tree, it is the exception rather than the rule. The percentage of figs thus attacked is very small, the larger part of the infestation taking place later, while the figs are drying on the "serghi" or are piled in the fig depots.

EGGS ON FIGS ON THE TREES.

It was evident that the "worms" were not present in any number in the figs when they dropped from the trees. But as they were known to appear in the figs a week or two after their dropping, and to be present in numbers when the figs arrived in Smyrna from the

[a] Beds of reeds or other suitable plants laid upon the ground to protect figs from contact with the soil while drying.

FIG. 1.—EXTENSIVE FIG ORCHARDS IN VALLEY OF CAYSTRUS RIVER, ASIA MINOR. THE FIG MOTH IS ABUNDANT OVER THIS AREA. (ORIGINAL.)

FIG. 2.—TYPICAL SMYRNA FIG ORCHARD IN MEANDER VALLEY, ASIA MINOR, WHENCE COME THE BEST FIGS FOR EXPORT. THIS IS THE REAL HOME OF THE FIG MOTH. (ORIGINAL.)

interior, there seemed a possibility that the eggs were laid before the figs dropped from the trees. To determine if this were the case, hundreds of ripe or ripening figs on the trees were examined, but no eggs were found.

The first search for eggs in an orchard was made at Nazli, Asia Minor, on August 8. The fruit was just ripening and none had begun to shrivel or dry. The figs were closely examined, but no sign of Ephestia eggs was found. Ten days later a similar search for the eggs was made in an orchard at Kara Bounar, and, although the figs were much riper than previously and many were shriveling and dropping to the ground, the examination was fruitless of results. Both the outside of the skin and the interior of the eye of many figs were examined, but nothing having the appearance of fig-moth eggs was discovered. On the following day at Nazli figs were again examined in the orchard where observations were made on August 8. Still no eggs were revealed, even by the use of strong hand lenses.

Many attempts were made to find eggs on figs on the trees in an orchard at Tchifte Kaive, between August 21 and 26. A great many figs were cut open and the scales about the eye examined one by one, but no eggs were revealed. Several times, while examining figs, small, white, globular objects were found adhering to the skin. These, superficially, resembled the eggs of Ephestia, but when put under a good lens proved to be secretions of honey from the substance of the fig that had hardened on the outside.

MOTHS IN THE ORCHARD.

While search was being made for eggs in the orchard at Nazli a careful watch was kept for adults. The bark of trees was inspected, and débris and trash piles about the orchard were disturbed with a hope of arousing the moths. At Kara Bounar, August 18, reeds upon which the figs were drying were fruitlessly turned over in search of moths. The same was done on a later visit to Nazli, and vegetation in a vineyard closely adjoining a fig orchard was well shaken, but no moths were aroused.

When it became too dark to see, trees were examined by use of electric bull's-eye lamps. Chrysopid adults were thus revealed in numbers, flying about the foliage, and had the fig moths been present they would without doubt have been revealed by the light.

All efforts to locate moths about the trees, either in daylight or by the use of bull's-eye lamps, having failed, it was decided to climb a fig tree with an ordinary lantern and lie in wait for the appearance of the moths among the branches or foliage. This was done on August 25 in an orchard at Tchifte Kaive. In an hour's vigilance two moths were attracted to the light and a third seen flying among the foliage. Such a scarcity of moths could not account for the

wholesale infestation of dried figs, even in the event that the eggs had escaped detection. The only possible conclusion was that less than 10 per cent, and probably less than 5 per cent, of infestation of dried figs originates while the fruit is on the tree.

OVIPOSITION ON FIGS DRYING ON THE "SERGHI."

The first fig-moth adults seen in the interior of Asia Minor were at Nazli on August 19. A careful search had been made for them by day and in the early evening throughout the orchard with no success. About 7 o'clock, while watching the "serghi" (see Pl. VI, figs. 1, 2), a few moths were noticed fluttering over the drying figs. They increased in abundance, and by 7.30 p. m. were hovering over the beds of figs by dozens. It was impossible to determine from what source they came. They showed a particular fondness for crawling down among the reeds beneath, as though to reach the figs from the underside. They were evidently all of one species, *Ephestia cautella*, although they varied somewhat in size.

Moths were observed the following evening in another orchard where the figs were laid on the bare ground to dry, in place of upon beds of reeds. It was expected that the moths would prove less abundant in this case, there being no reeds present or other shelter in which they could hide by day. The lack of shelter, however, made little difference, for at dark they began to gather over the figs as on the preceding night, and quite as abundantly. A few were noticed as they approached the figs, flying close to the ground. Evidently the moths have no particular hiding place in which to pass the day, but simply secrete themselves about rubbish or foliage near the ground.

Observations of the moths ovipositing on figs on the "serghi" were made during a week's stay, August 21 to 27, at Tchifte Kaive, Asia Minor. The "serghi" used in this orchard were sufficient in area to accommodate the drying of large quantities of figs. They were composed of reeds taken from near the Meander stream and laid in long rows, 3 feet wide and half as far apart. (See Pl. VII, figs. 1, 2.) Observations were easily made along any of these beds from the alleyways between. As observed on previous occasions, the moths began to appear at about 7 o'clock and increased in abundance up to 8 or 8.30 p. m. As late at 10.30 p. m. they were found still active, and doubtless continued ovipositing until well toward morning. Lanterns were employed to observe the moths, which seemed unusually abundant at this place. Occasional moths were attracted to the lanterns, but usually they avoided the light. They were quick in their movements and hard to capture.

No individual was seen depositing eggs, for upon alighting the moth invariably crawled quickly to the underside of the fig, and if

FIG. 1.—THE CRUDE FORM OF "SERGHI" EMPLOYED IN MOST ORCHARDS FOR DRYING FIGS. FRUIT IS EXPOSED TO THE SUN FROM 2 TO 5 DAYS. (ORIGINAL.)

FIG. 2.—NEAR VIEW OF FIGS DRYING ON THE "SERGHI," NAZLI, ASIA MINOR, AUGUST 19, 1910. THIRTY-FIVE PER CENT OF THE FIGS BECOME INFESTED ON THE "SERGHI." (ORIGINAL.)

disturbed would take wing. The moths varied greatly in size, some having twice the wing expanse of others. The smaller individuals seemed to predominate. The small ones were less distinctly marked than the larger ones, although all were of one species.

A few moths, after being left a short time in a cyanid bottle and partially stupefied, were taken out and put into glass jars with figs. They soon revived, and by morning each individual so confined had laid a large number of eggs. The eggs were laid indifferently on the skin of the fig or on the sides of the jars, and many had dropped to the bottom of the jars. Eggs were usually deposited in the creases or furrows in the skin of the fig or on wounds or injured parts where the larvæ would find little difficulty in entering the fruit. They were never seen to be deposited within the eye or aperture of the fig.

PERCENTAGE OF INFESTATION ON THE "SERGHI."

The figs are gathered night and morning as they drop from the trees, and the large number of moths attracted to the "serghi" may be explained by the absence of figs on the ground in the orchard, as well as by the strong fragrance emitted by so many figs piled together. Figs remain from two to five days on the ground drying, fully exposed to the sun. No precaution is taken to cover or protect them at night, so that they are exposed as many nights to the ravages of the moths.

A count was made at Tchifte Kaive, August 26, to determine the percentage of figs that become infested on the "serghi." Figs that had laid exposed for one night, two nights, and three nights were examined, 200 being counted from each lot. The number of eggs on each fig was not recorded, the presence of a single egg causing a fig to be considered as infested. The following degrees of infestation were found:

Exposure.	Number of figs.	Infested figs.	Uninfested.
Nights.		*Per cent.*	*Per cent.*
1	100	27	73
1	100	31	69
2	100	41	59
2	100	36	64
3	100	42	58
3	100	47	53

From these data it is apparent that in an exposure of one night 29 per cent of the figs become infested, in two nights 38½ per cent, and in three nights 44½ per cent. The average infestation for all figs not remaining over three nights on the "serghi" is therefore about 37 per cent.

INFESTATION IN FIG "DEPOTS."

As the figs are gathered from the "serghi" they are transported, (see Pl. VIII, figs. 1, 2) in goat's-hair bags or woven willow baskets strapped on the backs of horses or camels, to the villages, where they are dumped into large piles in buildings known as fig "depots." Here the different grades are mixed and resacked into other goat's-hair bags (see Pl. IX, fig. 1), and later loaded onto camels (Pl. IX, fig. 2) to be carried to the railroad station for shipment to Smyrna. The figs are brought to the "depots" in large quantities, and considerable forces of men and women are required to handle them. It is stated by the Turks, who have charge of the figs at this period of their manipulation and who look after their transportation to Smyrna until they are turned over to the commission men at the bazaars, that the figs never remain in these "depots" for more than 48 hours, and seldom longer than a single night. It would seem from this that the opportunity of infestation in the "depots" is necessarily small.

At about sundown August 24 a fig "depot" located at Tchifte Kaive was entered with the hope of determining whether or not the moths occurred there as abundantly as they did over the "serghi." Lanterns were used, and at about 6.30 p. m., at least 30 minutes before the appearance of the moths out of doors, they began to be active, and by 7 o'clock were fluttering in large numbers over the piles of figs and depositing eggs.

The moths are not present in these "depots" early in August before the figs have entered them. A large number of "depots" in the different villages was inspected early in August before dried figs had begun to enter them, and no sign of living Ephestia in either pupal or adult stages could be detected by the minutest examination of the dust and cobwebs in dark corners of the buildings. Unquestionably the moths are attracted into the "depots" by the odor of the first figs that enter. Finding the building to afford good shelter from heat, wind, and too much light, and furnished a fresh supply of figs each day from the orchards, they doubtless remain inside until the end of the season, increasing each day in abundance as new individuals enter from the outside. The moths are more abundant in the "depots" than outside over the "serghi," and it is astonishing that a single fig passing through the "depots" should escape infestation. If the figs were to remain for any length of time in the "depots," the amount of infestation resulting from so great an abundance of moths would prove almost startling.

INFESTATION IN FREIGHT CARS.

After leaving the "depots" the figs are tightly inclosed in goat's-hair bags until they reach Smyrna, and there is little chance for fur-

FIG. 1.—TEAM OF WATER BUFFALO AND DRIVER AND TURKISH CART, OFTEN USED FOR CARRYING FIGS. (ORIGINAL.)

FIG. 2.—FIGS ARRIVING AT A "DEPOT." BROUGHT FROM ORCHARD ON HORSEBACK BY PEASANT WHO GREW THEM. TCHIFTE KAIVE, ASIA MINOR. (ORIGINAL.)

FIG. 1.—FIGS OF DIFFERENT GRADES BEING MIXED IN "DEPOT" OF INTERIOR, AND RESACKED FOR SHIPMENT TO SMYRNA.

In these buildings much damage occurs from fig moths. Tchifte Kaive, Asia Minor, August 24, 1910. (Original.)

FIG. 2.—CAMEL CARAVAN CONVEYING FIGS FROM A "DEPOT" TO RAILROAD STATION IN INTERIOR OF ASIA MINOR.

At this stage from 50 to 75 per cent of the figs are infested with eggs or larvæ, many of which are destroyed by tight packing and rough handling. (Original.)

ther infestation by moths until they are again exposed in the "khans" of Smyrna. The railroad carries them in both open and closed cars, known as "wagons." (See Pl. X, fig. 1.) During the month of August a large number of these cars was inspected for evidences of the fig moth, either in the egg, larval, pupal, or adult stages; but nothing was discovered which would lead one to believe that the freight cars are in any way responsible for the infestation of the crop. Many cars, however, were found to be very dirty, and Dr. Yenidunia, director general of agriculture, requested the railroad authorities to have all wagons, or cars, intended for the shipment of figs from the interior to Smyrna thoroughly disinfected with chlorid of lime and water before using.

On August 26, after the issuance of this order by the railroad officials, a wagon was inspected at Tchifte Kaive and found to have been sterilized and to to be in every respect clean. A loaded car of figs was also examined and several of the bags disturbed, but no fig moths were seen. The bags of figs remain in these wagons but a short time, never longer than 48 hours, and are unloaded as soon as they reach Smyrna.

INFESTATION IN BAZAARS IN SMYRNA.

After their arrival in Smyrna the bags of figs remain only a few hours in the bazaars, before being carried to the "khans" and dumped. On several occasions during the month of October close inspection was made of the interiors of closed fig bazaars in Smyrna and of conditions surrounding the bags of figs in the open bazaars in the streets. Débris and dust about dark corners were disturbed and empty sacks, strewn about the ground, were turned over or shaken, but the number of moths aroused in this way was of no consequence. Few moths were present in or about these bazaars, and they were accidental. The bags, furthermore, are well covered at the top at night with cloth or paper, so that the chances are very slight of the figs having eggs laid upon them during their brief stay at the bazaars. (See Pl. X, fig. 2.) Bags of figs are not emptied at the bazaars and seldom remain there over 24 hours. Occasionally larvæ were seen crawling over the bags, but these had come from the figs within and had not hatched from eggs laid in the bazaars.

Visits were twice made to bazaars in the evening during October and search made with lanterns, but only a few straggling moths were seen. These could not account for any infestation of the figs.

INFESTATION IN THE "KHANS."

Beginning as early as August 6, before their cleaning and whitewashing began, the "khans" in Smyrna were often and repeatedly examined for traces of the fig moth in the larval, pupal, or adult

forms. No living pupæ were found at any time before October, those seen later having resulted from the same year's supply of larvæ. Empty cocoons were found in abundance in some of the "khans" before their cleaning, but these could have no possible bearing on the infestation of the coming crop.

During August and early September the figs as they reach the "khans" are apparently free from "worms," yet if many are broken open and examined they will be found to contain young larvæ. In October conditions are different. About piles of refuse figs many full-grown larvæ may be seen crawling up the walls. (See Pl. XI, figs 1, 2.) This is not due to the fact that larvæ are more abundant in October, but that the figs have remained so long inland that the larvæ have matured and are leaving the figs to pupate. A small percentage pupates within the figs, and the adults may even issue in October in the "khans," but these moths do not cause the infestation of the crop, and are too few in number and issue too late to do any damage.

The first adult seen in a "khan" was on August 31. A single individual was found and its presence was purely accidental. Later than the middle of September adults were occasionally seen about the "khans," but in very small numbers. They were as often seen in screened "khans" as in open ones, showing that they had largely issued from figs which came into the "khans" since the first of the season.

On different occasions piles of figs in the "khans" were watched by night with lanterns and in no case were more than 4 or 5 adults seen in an evening. When we compare this with the hundreds of moths seen flying over piles of figs in "depots" of the interior there can be little question where infestation begins.

INFESTATION IN STEAMERS DURING OCEAN TRANSIT.

Further opportunity for infestation occurs while the figs are en route to America. To determine positively if they are attacked at this period a large consignment of figs was accompanied from Smyrna to New York, frequent observations being made. No Ephestia adults were seen in the hold at any time, but larvæ were commonly observed that had escaped from the boxes of figs during shipment. (See Pl. XIII, fig. 2.) No larvæ were seen about the bags of "naturals," or unpacked figs. In fact, figs shipped in bags are generally so badly crushed and macerated that no larvæ can survive in them. (See Pl. XII, fig. 1, and Pl. XIII, fig. 1.)

THE PRINCIPAL SOURCE OF INFESTATION.

To summarize, infestation of the figs begins in or near the orchards in the interior of Asia Minor, before the dried fruit has reached

FIG. 1.—CLOSED RAILROAD CAR, OR "WAGON," USED IN TRANSPORTING FIGS FROM THE INTERIOR OF ASIA MINOR TO SMYRNA.

No infestation by fig moths is possible in these cars, owing to the perfect closing of the goat's-hair bags. (Original.)

FIG. 2.—AN INDOOR FIG BAZAAR AT SMYRNA.

Figs are not exposed to moth attack in the bazaars, owing to the sacks being well closed. (Original.)

FIG. 1.—PILE OF REFUSE FIGS IN A SMYRNA "KHAN."

On the walls above these figs fig-moth larvæ congregate in large numbers. (Original.)

FIG. 2.—GREEK WOMEN GRADING THE REFUSE FIGS IN A SMYRNA "KHAN."

All grades, however filthy and wormy, are exported for use as food. (Original.)

FIG. 1.—LARGE "PACIALE" OF NATURAL (DRIED) FIGS READY TO SACK FOR EXPORT, IN A FIG "KHAN" IN SMYRNA.

These figs are shipped in jute bags, and the larvæ that remain in them are destroyed in transit to America. (Original.)

FIG. 2.—NATURAL (DRIED) FIGS BEING WATERED AND MIXED, SHOWING METHOD OF HANDLING WITH WOODEN SCOOPS OPERATED BY MEN IN BARE FEET.

The salt water causes the larvæ to leave the figs and crawl up the walls. (Original.)

FIG. 1.—THOUSANDS OF BAGS OF NATURAL (DRIED) FIGS IN A SMYRNA "KHAN" INTENDED FOR EXPORT TO AMERICA TO BE MADE INTO "STRAWBERRY" AND FIG JAM.

Larvæ smother in these bags and do not escape from the figs. (Original.)

FIG. 2.—SKELETON CASES OF SMYRNA LAYER FIGS BOUND FOR AMERICA IN HOLD OF MEDITERRANEAN STEAMER AT GENOA.

Larvæ escape from the cases and pupate in the hold, but adults developing from them perish before the next year's figs are shipped. (Original.)

Smyrna to be packed. Out of 100 worm-infested figs, the larvæ in possibly 5 to 10 per cent of them might be traced to the tree, while the other 90 to 95 per cent of larvæ develop from eggs laid either while the figs are on the "serghi" or in the fig "depots" of the villages. The number of larvæ originating from eggs laid while the figs are in freight cars en route to Smyrna, in the packing "khans" of Smyrna, or in the holds of steamers en route to America, is inconsiderable.

METHODS OF CONTROL.

The real source of infestation determined, the question arises as to the best means of avoiding it. Spraying with insecticides or fumigating the trees by using tents is too expensive for the average peasant and would be, furthermore, of little use where so small a percentage of infestation occurs on the tree, unless these methods could be employed at a time when they would kill the first generation of the insect, which is confined exclusively to the orchard. Efforts must be directed to some means of destroying the adults that cause the infestation, or of reducing their numbers by a systematic attack upon the larvæ or pupæ from which they mature—i. e., by reduction of the early stages of the earlier broods of the moth in the orchard.

DESTRUCTION OF THE EARLIER BROODS OF THE MOTH.

Upon questioning a number of Turkish peasants at Tchifte Kaive it was learned that there is an earlier crop of figs produced by the majority of trees in the latter part of May and largely throughout June. These figs are rather larger than the drying figs that later appear on the same trees, but are insipid and much more watery, and, therefore, useless for drying purposes. Being of little export value, few, if any, of them ever reach Smyrna, so that such as are not used by the peasant for his own consumption are allowed to remain in the orchard and spoil on the ground. These figs are reported to be very "wormy;" in fact the Turkish word applied to the early crop, which to the merchants is known as the June crop, is a term meaning "wormy figs." There can be little doubt that the June crop of figs furnishes sustenance for the early broods of the fig moth, and is responsible for the myriads of moths which later appear to infest the valuable export crop ripening in August and September. How many generations of the moth breed in the June crop of figs it is impossible to say, but probably at least two.

It is of great importance that rigid regulations be enforced upon the peasants for the quick disposal or destruction of the June figs as they drop from the trees in order to diminish so far as possible

the number of moths which breed from them. Whether or not these figs can be put to any other use than simply being eaten raw by the peasants is yet to be learned, but if so it would be of great value and an effectual means of reducing infestation to the autumn or export crop.

PROTECTION OF DRYING FIGS.

Covering the figs at night, while they are drying on the "serghi," would very much reduce their "worminess." A practical way of doing this would be to adopt frames for the drying as used in California, which could be stacked one over the other each evening. Where this is found too expensive, a covering of cloth of mesh close enough to prevent oviposition, spread over the figs each evening and held down with weights, would do much to exclude the moths and thus prevent the deposition of eggs on the figs. But even this simple treatment, in order to give results, should be uniformly applied by all growers. The effect of such a treatment would be to divert the moths to the orchard; but their consequent scattering, and the much greater time that would be required for them to deposit eggs upon the same number of figs on the trees, would result in a marked diminution of the damage.

EXCLUDING MOTHS FROM FIG "DEPOTS."

As a special precaution against infestation of figs in the "depots," the latter were ordered by the director general of agriculture to be thoroughly disinfected throughout with chlorid of lime and whitewashed before any figs should enter them, as required in the packing "khans" of Smyrna. Measures of precaution such as these for the destruction of eggs and cocoons already in the "depots" are practically useless, as the buildings bear no living traces of the moths at the beginning of the season, and as practically no moths are brought in with the figs, the majority must enter by night through the open doors and windows. A careful screening of these and closing of all stray openings about the roof and under the gables in July or the early part of August, before the figs have entered, would exclude practically all moths from the fig "depots" and very considerably reduce the amount of infestation to figs.

DESTRUCTION OF EGGS ON FIGS.

Even with close adherence to the precautions advised above, namely, the covering of figs on the "serghi" and careful screening of the "depots," many figs will become infested with eggs before they leave the "depots," for the moths will find access to the fruit while on the tree, or while on the ground in the orchard before being

gathered. The only way to insure figs against some infestation is to destroy the eggs present on them before sacking them for shipment to Smyrna. An experiment was made to determine the temperature and length of exposure (boiling in salt water) necessary to kill the eggs.

From figs that had been exposed from one to three days on "serghi," at Tchifte Kaive, August 24, a large number was chosen bearing Ephestia eggs adhering to the skins. These were boiled, in small lots, in water containing 2.5 per cent of salt, for the following lengths of time at different temperatures:

Lot.	Exposure.	Temperature.		Lot.	Exposure.	Temperature.	
		°C.	°F.			°C.	°F.
1	30 seconds.	70	158	5	1 minute..	70	158
2	...do.....	80	176	6	...do.....	80	176
3	...do.....	90	194	7	...do.....	90	194
4	...do.....	100	212	8	...do.....	100	212

After taking them from the water they were hung in large-meshed bags to dry in the wind and sun. When examined August 25, the eggs in lots 3, 4, 6, 7, and 8 had entirely collapsed, and were partially collapsed or at least dented in lots 2 and 5. The eggs in lot 1 were apparently unharmed by the heat, but two days later were discolored perceptibly, and showed no signs of vitality. By September 3 larvæ were working in almost every lot of figs experimented upon, but these had undoubtedly hatched and entered the figs previous to the boiling, as they were too old to have come from eggs present on the outside of the figs when they were boiled. The conclusion is that boiling the figs in water containing 2½ per cent salt for an exposure to exceed 30 seconds and temperature to exceed 80° C. (176° F.) will kill all eggs on the outside of the fig, but will not kill larvæ within the fig, even though the temperature is increased 20° C. (36° F.).

DISCONTINUING THE RETENTION OF FIGS INLAND.

Between the fig "depot" of the interior and the packing "khan" of Smyrna measures of precaution against worm infestation are unnecessary, as the moths have no access to the figs while they are in the goat's-hair bags. Promptness in delivery to the packers is the all-important thing to be observed at this period of the fig's handling. Two weeks' delay brings most disastrous results. During this time the worms which have hatched from eggs laid on the "serghi" or in the "depots" are doing their worst damage and are growing rapidly to a size that renders their presence in the figs most offensive. Moreover, the physical condition of the fig is injured by delay in shipment to Smyrna.

After inquiry, the writer is convinced that the railroad is able to transport the fig crop direct to Smyrna as promptly as it comes to the villages from the orchards, and that the packers in Smyrna are quite as able to handle it as fast as it can be turned over to them. From our point of view there is no reason, therefore, why figs should be detained in the interior unventilated in the bags, or in piles in the fig "depots" exposed to moths, flies, and other sources of contamination. A week's time is more than sufficient for the figs to reach the packer after they have been gathered from the "serghi." Observations show that most of the crop is held in the interior some time after harvesting, in many cases more than a month. The object of this is to bring better prices to the growers and the middlemen, at the expense of the packers, and to correspondingly increase the revenues to the local Government, regardless of what the consequences may be to the product or to the consumer.

The practice of "holding" the figs by the producers and middlemen is of recent origin, and apparently is growing. So long as the responsible parties realize large profits from such a practice, as they undoubtedly do, it is not likely to be discontinued, except by stringent action on the part of those who consume the figs and are forced to pay highly for the injuries done. The packers are in no position to control the supply, and can do nothing better than to take whatever figs they can get from the peasants and their representatives, at such time and price as offers, charging a correspondingly higher price for the packed figs. Americans may expect in the future to pay a higher price for figs inferior to those now imported, unless some decisive action is taken to stop this unwarranted retention of the crop inland.

ELIMINATION OF LARVÆ IN THE "KHANS."

The Smyrna "khan" is not responsible for the wormy condition of figs. But as the packer is responsible for the fig reaching the consumer, he also must be held accountable for the condition in which it reaches the consumer. If the fig is laden with "worms," he must rid it of these before it can be imposed upon the public as a sanitary article of diet. The experiments conducted in the "khans" were undertaken with the hope of discovering a means by which the packers could profitably furnish the American importers with sanitary figs, free from fig "worms" or other insect pests.

In contemplating a means of eradicating larvæ from figs in the "khans" considerable dependence was placed upon the method used in this country for freeing flour mills of the related Mediterranean flour moth (*Ephestia kuehniella*), viz, by hydrocyanic-acid gas fumigation. After examining the "khans" several reasons were found why the fumigation method could not be used: (1) Whatever ventilation openings occur near the roofs in these buildings are not

FIG. 1.—A HAND VACUUM MACHINE FOR EXTRACTING AIR FROM JARS OF FIGS, AND ITS OPERATOR.

Larvæ do not survive in jars of figs so treated. (Original.)

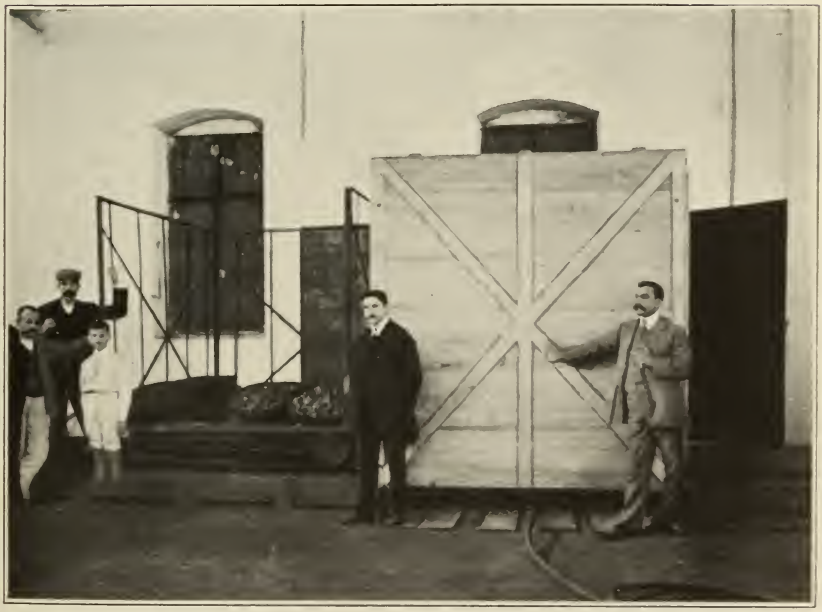

FIG. 2.—OVEN FOR STERILIZING FIGS BY DRY HEAT, WITH LOADING FRAME EXTRACTED; EMPLOYED IN A "KHAN" IN SMYRNA.

By subjection to dry heat a very large proportion of larvæ in the figs is destroyed. (Original.)

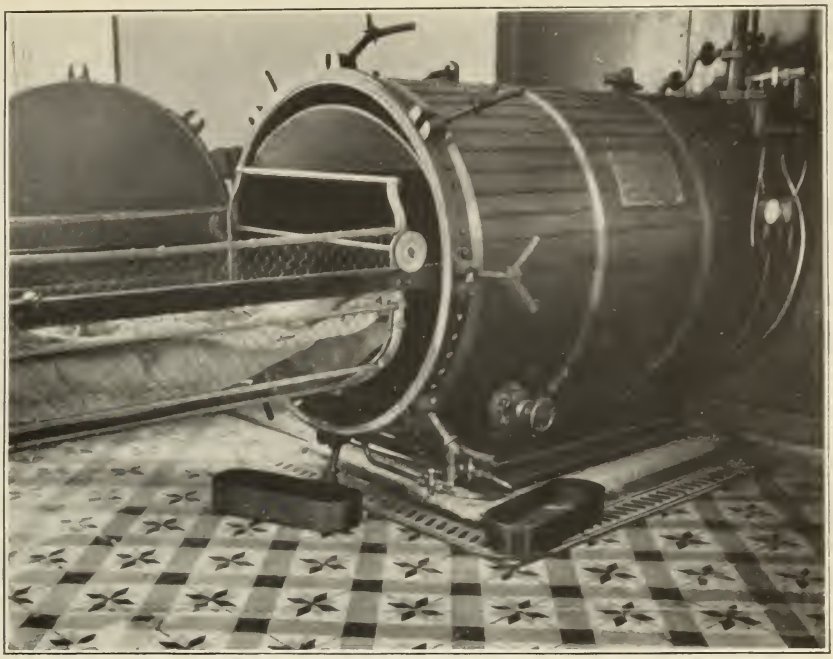

FIG. 1.—STEAM DISINFECTING CLOSET, WITH LOADING FRAME EXTRACTED, WHICH COULD BE EASILY ADAPTED FOR STERILIZATION OF FIGS AND DESTRUCTION OF FIG-MOTH LARVÆ. (ORIGINAL.)

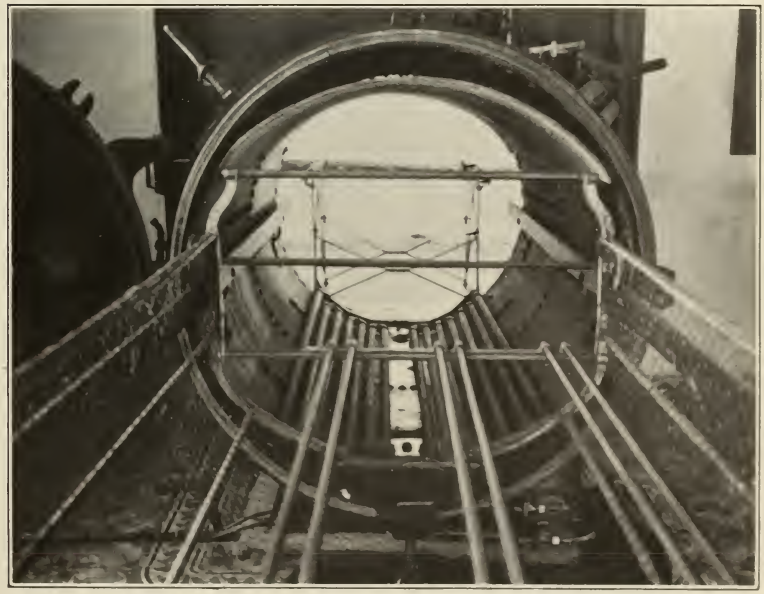

FIG. 2.—INTERIOR OF STEAM DISINFECTING CLOSET WITH ENDS OPEN AND LOADING FRAME EXTRACTED, SHOWING ARRANGEMENT OF PIPES WITHIN. (ORIGINAL.)

furnished with glass and are often so large that it is impossible to make them air-tight; (2) the supply of figs in a "khan" does not remain, but passes through in a very short time, usually a day or two, which would necessitate fumigating several times a week. This would be too expensive a process, as well as impracticable, because it would endanger the occupancy of the building the following day. The proportion of air space in a "khan" to the amount of figs to be treated would make fumigation totally impracticable (Pls. XII, fig. 2, and XIII, fig. 1), and the packers are emphatically opposed to subjecting their wares to the action of such deadly fumes as those of hydrocyanic acid.

EXPERIMENTS IN THE "KHANS."

The simplest possible treatment for the destruction of foreign life in any article of food, viz, subjection to heat, suggests itself as more economical and easier to apply than any other method. Experiments were made using three distinct methods of application, i. e., by steam, hot water, and hot air. The results obtained by using any of these do not vary greatly, though the details of the application, the required temperatures and lengths of exposure, and the drying where water is used, necessarily differ much. Experiments were also made using a vacuum treatment.

In conducting experiments for the eradication of fig-moth larvæ by various methods the writer was extended many courtesies by packers of figs in Smyrna, some of whom had been using the same methods with practical results for some time, and had apparatus in their establishments for the purpose. In one case an expensive sterilizing outfit was installed for the special purpose of making experiments to determine the practicability of subjecting figs to special treatment to kill the "worms." Among Smyrna fig packers, who seemed particularly interested in this phase of the fig industry and to whom the writer is indebted for material assistance in performing the experiments, may be mentioned Mr. John Manola, Mr. Aram Hamparzum, and the manager of his "khan," Mr. Vedova; Messrs. A. Reggio and sons, and Mr. S. A. Stassinopulo.

DESTRUCTION OF LARVÆ BY VACUUM TREATMENT.

Attempts were made to free the figs of "worms" by subjection to vacuum, but with little success. An experiment was performed on September 26, in a "khan" in Smyrna, to determine whether vacuum treatment could be successfully applied to layer figs in boxes to kill the larvæ present. A number of larvæ, found crawling up the wall above a pile of refuse figs, was inclosed in a fig jar, and put into a

vacuum machine, and the air extracted from the jar. (See Pl. XIV, fig. 1.) A day later the larvæ were alive and apparently healthy, but were quite inactive. On September 30 they were still alive and healthy, but seemed able to move only the fore part of the body, and that very feebly, spinning silk about them in apparent effort to make cocoons. When examined on October 8 they were in the same positions they had had a week previously; but by this time they showed almost no movement, at least no more than feeble agitation of the head, in evident discomfort. They had shrunken from their former size, and some had spun abundant silk; but none of them retained sufficient energy to spin a cocoon. They looked very sick, but were all living. By October 21 they were still more shrunken, and a few of them quite lifeless, though the majority showed by their color that they were not dead.

From the experiment it is plain that larvæ, though they might survive, would not continue to feed and to do damage if the vacuum were sustained about them. The application of a vacuum treatment to figs in boxes, however, would prove quite useless, since the larvæ would immediately revive and become active when brought back into the air. To render the larvæ inactive and thus innocuous, the vacuum must be long sustained, which is possible only by putting all figs in glass jars—a very expensive process.

RIDDING FIGS OF LARVÆ BY STEAM.

Experiments were made, October 6, to determine whether larvæ may be killed by subjection of infested figs to steam in confinement in a large steam disinfecting closet used in a Smyrna hospital for sterilizing clothing. The closet was tubular in form and horizontal, both ends opening to allow the entrance of one loading cage filled with clothing, while the other was being extracted at the opposite end for reloading. (See Pl. XV, figs. 1, 2.) The loading cages ran on rails on frames at each end of the closet, adjustable to similar rails inside. The steam was applied from an adjoining boiler, the pressure being allowed to reach about 10 pounds, at which point the temperature of the steam was 115° C. (240° F.).

A number of "natural" (dried) figs that showed traces of the presence of larvæ within them was introduced into the centers of two 25-pound jute bags of figs. The first bag was allowed to remain in the steam closet under full pressure of steam for 10 minutes, the second for 30 minutes.

When the first bag of figs was examined following the steaming the larvæ were found dead in all infested figs within 3 inches of the surface of the bag. Of 18 larvæ taken from figs at or near the center

only 3 were dead. Five more, that were stupefied, slowly recovered. In the bag exposed 30 minutes all larvæ near the surface were dead. Of 15 larvæ taken from figs at the center of the bag 13 were dead, or so badly injured that they did not revive, and the other 2 were sickly.

The following table gives percentages of larvæ killed by the steam at center of bag:

Temperature.		Exposure in minutes.	Number of larvæ.	After scalding.		Per cent killed.
°C.	°F.			Living.	Dead.	
115	239	10	18	15	3	17
115	239	30	15	2	13	87

When the bags of figs were taken from the steam closet they were badly soaked with water, those portions not dumped remaining wet for hours and the figs remaining very sticky and disagreeable.

Samples of figs scalded by steam were sent, about October 20, to Washington. At the time of sending, those scalded for 10 minutes were almost dry, while those scalded for 30 minutes were still damp. Examined by the writer in Washington, two months later, the figs were nicely sugar-coated; but it was noticed that all broken or injured figs, as well as many that were uninjured, were badly soured.

The conclusion is drawn that it is practically impossible to successfully sterilize figs by steam while in bags. The presence of so many soured figs among those experimented upon seems to make the practical use of steam doubtful, however well this destroys the larvæ. Artificial drying of the figs following their scalding would probably prevent the souring. Steam has an advantage over hot air in destroying larvæ in that a very short time is required to apply it and to raise the temperature to the degree desired. In addition, steam has more penetrative power than hot air, and hence requires shorter exposure of the figs.

SCALDING FIGS IN HOT WATER TO KILL LARVÆ.

The most extensive experiments were made with hot water. One fig-packing establishment in Smyrna has in operation apparatus for the sterilization of figs by boiling water, and good results were obtained from experiments made there in killing the larvæ. (See Pl. XVI, figs. 1, 2.) The required exposure is much shorter than for either steam or dry heat, and the subsequent drying easy. By this process a large percentage of the "worms" in figs can be destroyed without the additional expense in manipulation of much over a shilling (25 cents) per hundredweight, and if done on a large scale

the cost can be reduced. This estimate is based upon figures furnished by a packer who uses the process.

In the first experiment the exposure of the figs in the boiling water was very much undertimed. A number of figs infested with larvæ, selected from a pile of refuse and "hordas"[a] in a "khan," was immersed in boiling salt water (2.5 per cent solution, containing also some glucose) at 100° C. (212° F.) for short periods at varying temperatures, then put into jars and watched to determine what would later breed from them. The following table gives the temperatures and lengths of exposure and the number of larvæ that emerged at intervals of a week or more:

Temperature, lengths of exposure, and number of larvæ that emerged from scalded figs at intervals of a week or more.

Temperature.	Exposure.	Number of figs.	Number of larvæ present.						Per cent killed.
			Sept. 15.	Sept. 20.	Sept. 26.	Sept. 30.	Oct. 8.	Oct. 28.	
° *C.*	*Seconds.*								
100	10	10	.....	.....	1	2	3	4	60
90	10	11	2	3	7	10	11	13	0
80	10	11	1	2	2	7	7	7	0
70	10	8	.....	3	5	6	7	7	0
100	5	9	2	5	12	17	19	19	0
100	1	9	1	1	3	7	8	10	0
Check.	Check.	7	.....	2	3	5	6	9	0

Since the number of larvæ present in the figs before boiling was plainly variable, the only conclusion reached by this experiment is that an exposure of 10 seconds in water at 100° C. (212° F.), while it may reduce the number of larvæ in the figs somewhat, is quite insufficient to kill all of them, and that exposures for shorter periods or at lower temperatures than that are practically useless.

In another experiment figs similarly infested with larvæ were immersed in water containing $2\frac{1}{2}$ per cent of salt and a small amount of glucose, boiling at 100° C. (212° F.) for 20, 25, and 30 second periods. But these exposures, likewise, proved insufficient. Those scalded for 20 and 25 seconds, when broken open after the immersion, were found still to contain living larvæ. In the figs boiled 30 seconds that were broken open immediately the larvæ were apparently all dead.

[a] Figs which have failed to mature on the trees, and which consequently contain no sugar, being dry, hard, and flavorless.

FIG. 1.—COPPER BOILERS AND GALVANIZED STRAINERS USED FOR STERILIZING FIGS IN A SMYRNA "KHAN." THE PERCENTAGE OF LIVING LARVÆ IN THE FIGS IS MUCH REDUCED BY SCALDING. (ORIGINAL.)

FIG. 2.—INTERIOR OF OVEN FOR DRYING TRAYS OF FIGS WHICH HAVE BEEN STERILIZED BY BOILING, USED IN A FIG "KHAN" IN SMYRNA. (ORIGINAL.)

The following table shows the number of fig-moth larvæ that later developed from figs boiled in this experiment:

Temperature.	Immersion.	Number of figs.	Immediate effect.	Larvæ present Oct. 28, 1910.	Per cent killed.
° *C.*	*Seconds.*				
100	20	18	Larvæ living.....	11	39
100	20	18	.....do.....	[a] 8	56
100	25	17	Mostly living.....	7	59
100	25	17	.....do.....	10	41
100	30	14	Mostly dead.....	[a] 5	64
100	30	14	.....do.....	10	29

[a] Omorga.

Examination of the figs immediately following the immersion would seem to show that a much larger percentage of the larvæ is killed by an exposure of 30 seconds in the water than by shorter exposures, though the number of larvæ breeding from figs scalded for 30 seconds does not lead to the same conclusion. The percentages killed can not be accurate, since in figuring them it is assumed that each fig contained a single larva, when in fact the number of larvæ in a fig is variable. Plainly an exposure of 30 seconds of infested figs in boiling water is not sufficient to kill all larvæ within the figs. Unfortunately, this fact was not established by the emergence of larvæ from the boiled figs until the season was too far advanced to make further experiments allowing longer exposures in the hot water.

If larvæ were not killed in figs immersed for 30 seconds in boiling water it was because the heat did not penetrate to the interior of the fig in that length of time, for contact with water at boiling temperature causes immediate death to any larva. To determine how many seconds or minutes are required after immersion for the interior of the fig to rise to the temperature of the water, the bulb of a high-temperature thermometer was inserted to the center of 3 large figs successively, which were immersed in water at 100° C. (212° F.) and the temperatures recorded every half minute. The first fig was immersed in a large sterilizing kettle at a "khan" and the temperatures recorded for only 7½ minutes. The others were immersed in a small vessel of boiling water in the laboratory and the temperatures recorded for periods of 16 minutes.

The following table gives the rate of rise in temperature of the interior of the three figs and the resultant average rise. The average for periods of over 7½ minutes is taken from two figs only:

	Temperature readings.			Average temperature.		Rate of increase in temperature.
	No. 1.	No. 2.	No. 3.	Centigrade.	Fahrenheit.	
Minutes.	°C.	°C.	°C.	°	°	°C.
(a)	45	20½	20½	28⅓	83	.....
½	50	27	28	35	95	12
1	55	41	39½	45⅙	113	18
1½	60	53	49	54	129	16
2	65	63	57	61⅔	143	14
2½	70	71½	63½	68⅓	155	12
3	74	77½	69	73⅓	164½	9⅓
3½	78	82½	74	78⅙	172¾	8¼
4	81½	86½	77¾	82	179½	6¾
4½	84½	89½	81¼	85	185	5½
5	86	92	83¾	87¼	188¾	3¾
5½	87	94	86½	89	192	2¼
6	88	96	88½	90⅚	195	2
6½	89	97½	90¼	92⅓	197¾	1¾
7	90	98¼	91⅔	93⅓	200	1¼
7½	91	99¼	93½	94⅓	202	1
8	.....	100	94½	97¼	207	.....
8½	.....	100½	95½	98	208½	1⅓
9	.....	101	96½	98⅔	209⅝	1⅓
9½	.....	101⅜	97½	99⅝	211	1⅓
10	.....	101¾	98½	100	212	1
10½	.....	102⅛	99	100½	213	1
11	.....	102⅜	99½	100⅞	213⅔	⅔
11½	.....	102⅝	100	101⅓	214⅓	⅔
12	.....	102⅞	100⅜	101⅝	215	⅔
12½	.....	103	100¾	101⅞	215½	½
13	.....	103⅛	101⅛	102⅛	216	½
13½	.....	103¼	101½	102⅜	216½	⅓
14	.....	103⅜	101⅝	102⅝	216⅝	⅓
14½	.....	103⅜	102¼	102⅞	217	⅓
15	.....	103⅜	102½	103	217¼	¼
15½	.....	103⅜	102¾	103¼	217½	¼
16	.....	103½	102⅞	103¼	217¾	¼

a At immersion.

Since the rise of temperature was variable in the three figs, to reach more nearly the exact rate of rise an average was taken of recorded temperatures from all. Thus, for the interior temperature to reach 90° C. required in the first fig 7 minutes, in the second 5 minutes, and in the third 6½ minutes. For the interior of the average fig to reach 90°, therefore, would require about 6 minutes.

That 100° C. is necessary to cause immediate death to larvæ does not mean that figs must be boiled 10 minutes to kill the larvæ in them. Larvæ will as surely succumb to a temperature of 90° C., if sustained for a longer period, as to 100° C. in a short period. The accumulative heat at lower temperatures of the fig up to the point where the "required" temperature is reached has a decided devitalizing effect upon the larva. In boiling figs, larvæ will perish some time before an interior temperature of 100° in the figs is reached. Therefore it must be learned by further experiment what temperatures below 100° C., sustained for what lengths of time, will prove

fatal to larvæ before it can be stated exactly how long figs must be boiled to kill the larvæ inside of them.

Many packers complain that figs which have been boiled in hot water sour in a few weeks. If this be true, it is because the figs are boiled too long, i. e., longer than is necessary to kill the insects. Figs scalded by the writer in early September had up to December 20 shown no indication of souring.

The experiments that were made to determine the exact effect upon figs of boiling them to kill insect larvæ were performed in one of the larger "khans" in Smyrna. Two 5-pound boxes of layer figs, one of "4-crown" and one of "7-crown," and another box of "Locoum" figs were boiled and packed in the presence of the writer. Three identical boxes of figs that were not boiled were also packed the same day for use in "checking" the experiment, and all were shipped to Washington, D. C., for later observation and comparison. The figs were scalded in a 2.5 per cent salt solution at a temperature of exactly 100° C. (212° F.) (taken by a high-temperature thermometer) for 10 seconds, then drained and put into a screen-bottomed drying tray and immediately carried into the packing room. When first taken from the hot water they had apparently absorbed a small amount, making the skin semitranslucent. Packing began exactly 5 minutes after the scalding. By this time all excess moisture on the outside had evaporated except that held in the cracks and folds of the skin. Ten minutes later the remaining moisture had also evaporated. At this stage the figs differed from those not scalded in that the skin was quite translucent, as though retaining a small amount of moisture, and in being rather less sticky and far softer and more flexible, and easier to pack into layers.

When the boxes of scalded figs were opened up the following January and February in Washington they were in prime condition and noticeably free from attack of larvæ. The only objections to them were their stickiness and a very slight flavor of acidity noticeable in some figs. In spite of these objections they were cleaner and much preferable to the figs not boiled.

Some packers contend that boiled figs are darker in color and, therefore, less desirable; but so long as the figs are not injured in quality by the boiling, it is reasonable to believe that their freedom from "worms" will more than compensate the loss in color. Almost all packers boil the figs intended for their own consumption, but strangely can not afford to boil those intended for sale, or find reasons not to do so.

APPARATUS FOR STERILIZING WITH HOT AIR.

Dry heat has proved to have advantages over the hot-water method. The time wasted in the subsequent drying of the figs is eliminated,

and there is less tendency for the fruit to acidify, as occasionally occurs when it has been boiled. The color, too, is if anything less affected by dry heat; though this is difficult to determine positively, as experiments were made with a different lot of figs from those boiled, and under different conditions. The disadvantage of the dry-heat process as compared with hot water is the much greater exposure required, since time is an important item in the figuring. It is also more difficult to maintain a uniform temperature. Another respect in which the dry process is inferior is that it does not remove filth and destroy microbes on the outside of the fig, as does boiling.

At a large khan in Smyrna has been installed an oven, heated by gas, for experimental work in the destruction of fig-moth larvæ in figs. The dimensions of the oven are 2 by 2 meters by 3 meters long. Both ends open out, and are furnished with double doors that swing vertically. Passing through the oven is a track of two rails $1\frac{1}{4}$ meters apart, on which run two iron loading frames on wheels. The capacity of each frame is about 4 to $5\frac{1}{2}$ tons, depending on whether the figs are loaded in sacks or in the woven baskets piled one above the other. The object of having two frames is that one may be reloaded while the other is within the closed oven and the figs are being sterilized. The oven is made of sheet iron 4 mm. thick. The doors are covered outside with sheet asbestos, with an air-space $1\frac{3}{4}$ inches in depth between it and the sheet iron. The sides and top are covered with white planking three-fourths of an inch thick set out from the sheet iron, with intervening air spaces of depths of $6\frac{1}{4}$ and $4\frac{1}{2}$ inches respectively at sides and top. The object of the air spaces is to prevent burning of the wood and radiation and loss of heat. Paper put into these air spaces, with asbestos next the iron, would still further conserve the heat. The oven is heated by gas, which is furnished by a large series of burners on a sliding frame that passes under the oven. Two thermometers are inserted in one of the doors, by which the interior heat may be determined and regulated. The entire cost of the oven was about £400, and the cost of the gas is about £3 for each 10 hours of use.

Considerable loss of heat accompanies each opening of the doors and insertion or extraction of the loaded frames. To ascertain the extent of this loss and the relative length of time required for the heat to again rise to a point sufficient to kill larvæ, a loaded frame was inserted in the oven and a tabulated record made of the temperatures, taken at intervals of every quarter or half minute during its exposure of 10 minutes and an additional period after its extraction.

The following figures give the temperatures of the interior of the oven before and during the introduction of the figs, and the

time required for the temperature to rise after the figs are removed:

	Time.	Temperature.		Rise (+) or drop (−) each half minute.
		°C.	°F.	°F.
Doors opened	11.50 a. m.	132	270	.....
Figs introduced	11.50½	120	248	.....
Doors closed	11.50½	110	230	−40
Figs in oven	11.50¾	100	212	.....
Do	11.51	97	207	−23
Do	11.51½	95	203	− 4
Do	11.52	94½	202	− 1
Do	11.52½	95	203	+ 1
Do	11.53	96	205	+ 2
Do	11.53½	98	208	+ 3
Do	11.54	100	212	+ 4
Do	11.54½	102	215	+ 3
Do	11.55	103	217	+ 2
Do	11.55½	104	219	+ 2
Do	11.56	105	221	+ 2
Do	11.56½	106	222½	+ 1½
Do	11.57	106⅔	224	+ 1½
Do	11.57½	107½	225½	+ 1½
Do	11.58	108¼	227	+ 1½
Do	11.58½	109	228¼	+ 1¼
Do	11.59	109⅔	229⅔	+ 1⅓
Do	11.59½	110½	231	+ 1⅓
Do	12.00 noon.	111¼	232¼	+ 1¼
Doors opened	12.00½ p.m.	112	233½	+ 1¼
Figs removed	12.01	94	201	−32½
Doors closed	12.01½	92	197½	.....
Oven empty	12.01½	92	197½	− 3½
Do	12.01¾	94	201	.....
Do	12.02	97	206½	+ 9
Do	12.02¼	100	212	.....
Do	12.02½	104	219	+12½
Do	12.02¾	108	226	.....
Do	12.03	111½	232	+13
Do	12.03½	117½	243	+11
Do	12.04	121½	251	+ 8
Do	12.04½	125	257	+ 6
Do	12.05	128	262	+ 5
Do	12.05½	130¼	266	+ 4
Do	12.06	132	269½	+ 3½
Do	12.06½	133½	272½	+ 3
Do	12.07	135	275	+ 2½
Do	12.07½	136	277	+ 2
Do	12.08	137	279	+ 2
Do	12.08½	138	280½	+ 1½
Do	12.09	138⅜	282	+ 1½
Do	12.09½	139½	283	+ 1
Do	12.10	140	284	+ 1
Do	12.10½	140½	284½	+ ½
Do	12.11	140⅝	285	+ ½
Do	12.11½	140⅝	285¼	+ ¼

The results of the experiment are more variable than constant. The temperature dropped 40° F. during the first opening of the doors, and 28° more after the doors were closed, due no doubt to the heat required to bring the frame and figs up to the temperature of the oven. During the second opening of the oven the temperature dropped 36°, and rose immediately, as no more figs were introduced, hence no heat absorbed, after the doors were closed. From the minimum heat, 202° F., to the maximum heat, 233.5° F., the temperature of the loaded oven rose 31.5° in 8 minutes. The temperature of the empty oven rose 85.5° in the same length of time, or from 197.5° to 283° F.

The following table gives some idea of the comparative time required for the temperature to rise in the loaded and empty ovens:

	Temperature when doors closed.	Minimum temperature.	Maximum temperature.	Average temperature in 10 minutes.	Total rise in 10 minutes.	Average rise per minute.	Average rise, minimum to maximum.
Loaded	110° C. 230° F.	94½° C. 202° F.	112° C. 233½° F.	103¾° C. 219° F.	2° C. 3½° F.	⅕° C. ⅜° F.	2½° C. 4° F.
Empty	92° C. 197½° F.	92° C. 197½° F.	140⅝° C. 285¼° F.	127½° C. 260½° F.	48¾° C. 87¾° F.	4 9/10° C. 8 1/10° F.	4 9/10° C. 8 1/10° F.

To establish definite laws for the working of the oven upon this experiment would be dangerous. If the rise in temperature of the loaded oven were uniformly 4° F. per minute after the minimum had been reached, the conclusion would be that in order to maintain the temperature of the oven it must be allowed to rise 68° between reloadings, which is the amount of heat lost during and following the reloading. If the total rise in temperature of the loaded oven is only 3.5° in the first 10 minutes, then the figs must remain in the oven at least 16 minutes longer in order for the oven to regain, at a rate of 4° per minute, the other 64.5° of the 68° lost. This would require a total exposure of the figs of 26 minutes. But as the rise in temperature of the loaded oven would without doubt accelerate after the minimum heat had been well passed, the real required exposure of the figs would be between 20 and 25 minutes. If the figs were exposed longer than this, with the gas burning at the rate employed in the experiments, the heat of the oven would increase or accelerate with each load of figs until a certain constant of equilibrium was reached. This constant could, however, be regulated by limiting the flow of gas and thus cutting down the source of the heat.

SUCCESS OF HOT-AIR TREATMENT IN KILLING LARVÆ.

A number of experiments was made to determine the temperature and length of exposure necessary to destroy larvæ by dry heat in an oven. The first of these was performed on September 21 in Smyrna, using the oven described above. A number of figs showing the presence of larvæ was chosen from a pile of refuse in a "khan" and subjected to dry heat for varying lengths of time at different temperatures.

The following table gives the lengths of exposure, the temperatures, and the number of larvæ that issued from the figs after treatment:

Temperature.			Average temperature.	Length of exposure.	Number of figs.	Number of larvæ present.		Per cent killed.
Maximum.	Minimum.	Average.				Oct. 16.	Oct. 28.	
°C.	°C.	°C.	°F.	*Minutes.*				
132	92	112	233	20	13	0	0	100
121	93	107	224	15	8	0	0	100
112	94	103	217	10	8	0	1	87
94	82	88	190	5	10	8	14	0

It is plain that any exposure to exceed 224° F., for 15 minutes, will destroy the life of practically all larvæ present in the figs. This exposure, however, apparently has no injurious effect upon the fruit.

A quantity of figs sterilized in the same oven by the management of the "khan" in which it is located was shipped to one of their New York representatives for examination and report. These figs were exposed for 15 minutes at an average temperature of about 212° F. Six boxes of them were forwarded to the Lederle laboratories, whose report on their condition, dated November 1, 1910, is summed up in the following table:[a]

Treatment.	Style of packing.	Number of figs.	Percentage showing evidences of larvæ.	General condition of the figs.
Unsterilized	Layer	100	12	
Sterilized	do	100	None.	Less fermentation in top layers. More fermentation in bottom layers.
Unsterilized	do	84	6	Contain living molds.
Sterilized	do	89	None.	Clean and moist; no molds. Slightly greater fermentation.
Unsterilized	Macaroni	85	79	
Sterilized	do	68	56	Slightly greater fermentation.

In the layer figs sterilization by hot air destroyed all larvæ in the two boxes examined. In case of the "macaroni" figs the same treatment reduced the number of larvæ present over 25 per cent without perceptible injury to the figs. These results argue very strongly for the use of dry heat, in preference perhaps even to steam or hot water, in ridding dried figs of the objectionable larvæ.

PRACTICABILITY OF STERILIZING ALL FIGS IN SMYRNA.

Some packers hold that in sterilizing figs the dead bodies of larvæ remain to decay inside the fruit, whereas if not killed the larvæ

[a] These figures were given by kind permission of a dealer of figs in New York City.

escape from the boxes during transit to America, leaving behind only their borings and excrement. This objection is not a reasonable one: First, because in fact a very small percentage of larvæ escapes in transit, the majority remaining within the boxes and crawling over and littering many more figs than are required for their sustenance; secondly, the body of the dead larva either dries or becomes perfectly preserved by the sirup of the fig and indistinguishable from it, leaving no outward trace to indicate its presence in the fig. The larvæ are not injurious when eaten with the figs, the objection to them being the unsightly condition their work gives to the fruit. If figs are delivered to the packers promptly from the interior, i. e., within a week after being gathered, the majority of larvæ will be too small to be objectionable or even distinguishable at the time the figs are sterilized.

As attested by a number of the large fig packers in Smyrna, the installation of machinery adequate to sterilize the entire output of packed figs from a "khan" is quite possible. Packers are, moreover, willing to proceed immediately toward that end if sterilization of figs (or whatever term we choose to use for the process of killing the "worms") is insisted upon and imposed with equal rigidness upon all. So long, however, as some packers can find means of evading the trouble and expense of sterilizing, and are thus enabled to undersell those packers who are put to extra expense in improving their product, and are at the same time assured of being able to sell their figs—or are perhaps even given a preference by some American importers because of the lower price they quote—it is not likely that much advance will be made in the way of sterilization. These things alone keep many packers from investing on a large scale in improvements that would greatly benefit the trade. In order to progress they must have the protection of this Government.

Without such action as can be taken against the fig moth in the "khan," the insect will only with the greatest difficulty be eradicated or even greatly reduced in number in figs coming to this country. There are several species of parasitic enemies of the fig moth present in Asia Minor, and often as high as 40 to 50 per cent of the larvæ are destroyed by them; but, as in all similar cases of insect parasitism, the eradication of the host is accomplished after the worst of the damage has been done. The larvæ, until they are full grown and about to leave the figs to pupate, do not succumb to the attack of parasites. The combined activities of all the parasites prove to be of little service in relieving the "wormy" condition of figs, so we must depend exclusively upon artificial means.

SUMMARY OF PREVENTIVE MEASURES.

In summing up the measures which will prove most instrumental in the eradication of the fig moth, we find that they fall into two classes—those of prevention and those of destruction. In the first class there are four very important measures to be observed: (1) The rapid disposal or destruction of the June crop of figs; (2) the covering of the figs at night while on the "serghi"; (3) the screening of the fig "depots" in the interior; (4) the prompt delivery of the figs to the "khans" after they are gathered. These are all extremely difficult to enforce, especially in a country like Turkey, where superstition is the ruling law of the lower classes. Without special legislation on the part of the Turkish Government we can scarcely hope for any decided change, for some time to come, in the customs that now prevail. The last of these four measures of prevention—the prompt delivery of the figs to the packers—*should be insisted upon* in so far as possible. Since dependence must be placed upon destroying the larvæ in the figs, it is highly desirable that the larvæ be no older and larger than necessary when killed, if it is intended to save the appearance of the fruit.

Of the three methods mentioned for destroying the fig-moth larvæ in the "khans"—by steam, hot water, or dry heat—it remains for the packers to demonstrate by actual experience which is the more practical. Experimentation has shown that each method has its advantages, and each is capable of eradicating the larvæ under proper conditions. It would be well to determine the temperature and length of exposure necessary to kill the "worms," and leave to the option of the packer what method he may prefer. It must be emphatically understood that prompt and decisive action is necessary on the part of one or both of the Governments interested if any decided improvement is to be expected in the present methods of manipulation and packing of figs, of a character that will insure their freedom from larvæ.

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